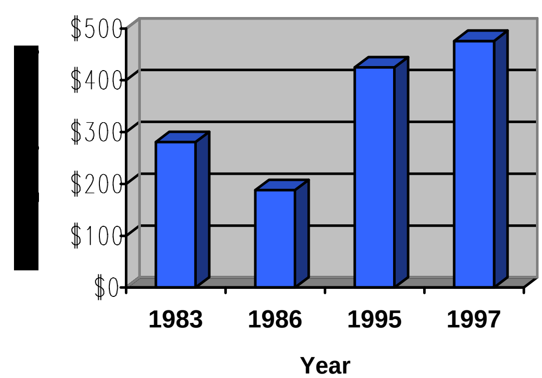
Why Is a Plan Needed?

The Sacramento and San Joaquin River Basins Comprehensive Plan is the result of landmark efforts to guide modifications to the flood management system in these two basins. The goals of the Comprehensive Plan are to reduce threats to public health and safety, reduce flood damages, and restore the ecosystem along the floodplain corridors. The Reclamation Board of California and the U.S. Army Corps of Engineers (Corps) began working together in 1998 to prepare the Comprehensive Plan.

California's Sacramento and San Joaquin River basins comprise one of the world's most diverse regions. This 43,000 square-mile watershed covers most of California's Central Valley. The watershed is home to more than four million people and a wide variety of fish and wildlife, including about 378 special-status plant and animal species. The river basins provide drinking water to over two-thirds of Californians. The robust economy of this region is centered on an agricultural industry that is a major source of reliable, high-quality crops used by the nation and the world. Flood risk in this region is rising, as are conflicts between maintenance of the existing flood management system, a rapidly-growing population, and ecosystem needs.

Purpose and Need for the Comprehensive Plan

In January 1997, Californians experienced one of the most geographically-extensive and costly flood disasters in the State's history. Major storms throughout the State caused record flows on many rivers and triggered loss of life and catastrophic property damage. Levees on the Sacramento River and its tributaries sustained two major breaks and were near failure in many locations. On the San Joaquin River, levees failed in 27 locations. These failures caused significant damages in both basins. The event was one of four major floods that have caused billions of dollars in damages to the Central Valley in the last two decades.

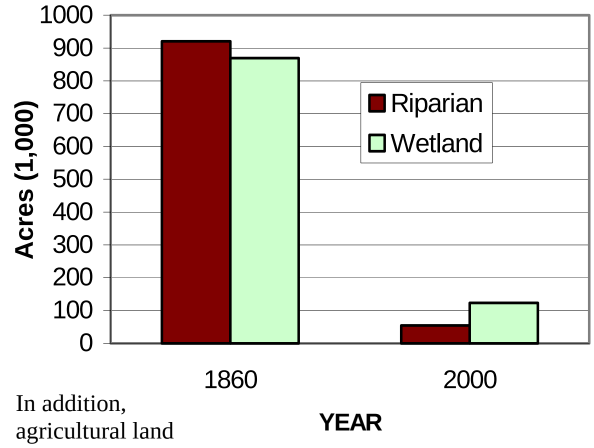


Flood Damages Caused by Recent Flood Events in the Sacramento and San Joaquin River Basins

Source: *Sacramento and San Joaquin River Basins, California, Post-Flood Assessment*, U.S. Army Corps of Engineers, Sacramento District, March 1999.

Wetland and riparian habitats in the Central Valley have declined to less than five percent of their original acreage. The ecosystem has also suffered from the extensive degradation of natural hydrologic functions. In 2000, the CALFED Bay-Delta Program identified their ecosystem vision including restoration of the riverine ecosystem. The CALFED vision is dependent on modification of the flood management system to support the ecosystem processes and habitat necessary for a healthy ecosystem. The CALFED Record of Decision (ROD) deferred consideration of changes to the flood management system to the Comprehensive Study.

Although the Corps has estimated that the existing flood management system prevented more than $38 billion in damages in recent flood events, the system still does not meet the region's current and future needs. For an effective and efficient solution, flood damage reduction and ecosystem restoration need to be integrated into the same solution.



In addition, agricultural land provides additional seasonal wetlands.

Historic habitat areas in the Sacramento and San Joaquin River Basins have declined.

Source: Sierra to the Sea – The Bay Institute of San Francisco

Authorizations for the Comprehensive Study

In response to concerns primarily raised by the 1997 flood, the Governor of California formed the Flood Emergency Action Team (FEAT). In its May 1997 report, the FEAT recommended developing a "new master plan for improved flood control in the Central Valley" of California. The California State Legislature (September 1997) and U.S. Congress (1998) subsequently authorized the Sacramento and San Joaquin River Basins Comprehensive Study. The House Report 105-190, accompanying the 1998 Energy and Water Development Appropriations Act, Public Law (PL) 105-62 called for "development and formulation of comprehensive plans for **flood control and environmental restoration** purposes."

What is Ecosystem Restoration?

"Ecosystem restoration" does not entail recreating any particular historical configuration of the riverine ecosystem of the Sacramento and San Joaquin rivers; rather, it means reestablishing a balance in ecosystem structure and function to meet the needs of plant, animal, and human communities while maintaining or stimulating the region's diverse and vibrant economy.

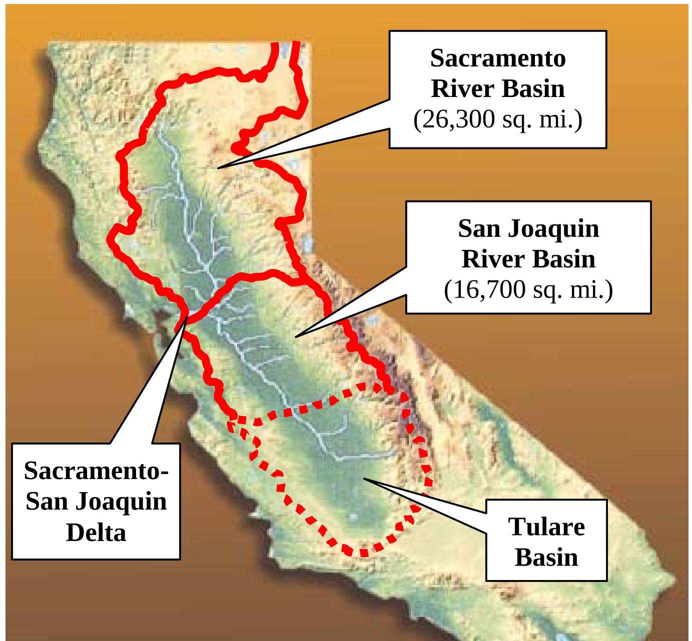
In addition, the Water Resources Development Act of 2000 directed the Secretary of the Army to "integrate, to the maximum extent practicable and in accordance with applicable law, the activities of the Corps of Engineers in the San Joaquin and Sacramento River basins with the long-term goals of the CALFED Bay-Delta Program."

The CALFED Bay-Delta Program (CALFED) began in 1995 to provide an institutional framework for reducing conflicts over water use and management in the Sacramento and San Joaquin River Delta - San Francisco Bay estuary. The CALFED mission is to *"develop and implement a long-term comprehensive plan to restore ecological health and improve water management for beneficial uses."* To accomplish their mission in the Bay-Delta, CALFED has identified four resource management areas that must be addressed. These include the need to improve ecosystem restoration, water supply reliability, water quality, and levee system integrity.

Attainment of the CALFED Ecosystem Restoration Program goals depends largely on modifications to the flood management system.

Basic Study Area

The Comprehensive Study area (shown below) includes the combined watersheds of the Sacramento and San Joaquin River basins. The study focuses on solving flooding and ecosystem problems within the floodplains of the Sacramento and San Joaquin rivers and the lower reaches of their major tributaries. The Tulare Lake basin is not included in the study area, although the contribution of flood flows from the Kings River to the San Joaquin River is considered. Flooding and related ecosystem problems on the Mokelumne, Calaveras, Cosumnes, and American rivers, and Cache Creek and other small streams are being addressed in other studies and are, therefore, not a primary focus of the Comprehensive Study. The study area for the Comprehensive Study is totally contained within the CALFED study area.



Study Area - Sacramento and San Joaquin River Basins

Public and Agency Participation

Throughout the five-year study, the focus of public and agency participation mirrored the progression of the study. During the first two years, this participation focused on collecting information on system-wide problems, particularly from those who work with the flood management system. During the third year, the participation focused on verifying the appropriateness of baseline conditions. The fourth year focused on conducting evaluations to determine how the system might respond to some modifications. The last year of the study focused on development of the Comprehensive Plan.

Comprehensive Study Outreach Tools

Information reached potentially interested parties through:

- Brochures
- News releases
- Newsletters
- Fact sheets
- Issue papers
- Meetings
- Briefings
- Workshops/Forums
- Draft reports
- Website: www.compstudy.org

Public and agency stakeholder interests vary widely across the extensive geographic area. For example, the interests of a landowner living adjacent to a levee and facing the risk of flooding is quite different than those of a person living outside the study area and primarily interested in the recreational or ecosystem benefits of the river system. Each agency or levee-maintaining district has different needs and responsibilities. This diversity of interest, throughout California's Central Valley, presented a major challenge for the Comprehensive Study to reach a representative sample of interested people.

To begin developing a better understanding of the rivers as a system and its problems, experts with Federal, State, regional flood control associations, environmental groups, academia, and other local experts participated in the Comprehensive Study via a set of technical and local support groups. These groups helped identify potential solutions to problems. Regional and local representatives of irrigation districts, flood control districts, water districts, utility districts, and operators of upper watershed reservoirs provided input on the system-wide hydrology and hydraulic models.

The Comprehensive Study included twenty-two general public workshops and forums to present information and obtain public feedback. Also, the Comprehensive Study team members regularly provided updates at many public hearings, agency meetings and other forums, including national and regional technical conferences. In addition, Comprehensive Study team members provided updates to various audiences upon request, including briefings to local, State and Federal public officials throughout the study.

Public Workshops

Conducted twenty-two public workshops and forums throughout the study area:

- Redding (1)
- Red Bluff (2)
- Chico (3)
- Colusa (2)
- Yuba City (2)
- Sacramento (3)
- Modesto (3)
- Fresno (3)
- Los Banos (3)

A policy focus group began to identify issues and institutional barriers that affect implementation of flood damage reduction, associated land use planning, and environmental restoration. The process for identifying and resolving implementation issues will continue and include all interested parties. Coordination with stakeholders revealed that although there is general agreement on the merit of a comprehensive system-wide solution, agreement is lacking on the specific physical components of such a project. Feedback from public coordination indicated that, on average, stakeholders prefer a process that guides development of locally- and regionally-driven projects, as opposed to an agency-driven system-wide physical plan.

The most meaningful opportunities for public and agency participation are in the future during planning for specific projects. Each project will need active public and agency participation to be successful. The outreach effort will have three fronts: (1) information/education on the evolving system-wide conditions and broad opportunities within the flood management system, (2) regional outreach as regional stakeholders are ready to plan large regional projects, and (3) project-specific outreach.

Past Reports

At direction from Congress, the Comprehensive Study first produced the March 1999 *Post-Flood Assessment* describing the economic effects of four major floods. The March 1999 *Interim Report* summarized the study progress and the companion *Documentation Report* presented the study in detail. Collectively, these reports identified flooding and ecosystem-related problems. In May 2001, an *Information Paper* summarized the analyses and described considerations necessary to develop a system-wide, physical "Master Plan."

This document summarizes study findings, a process that guides future project development, and a strategy to implement the process.

Historical Perspective

Prior to the discovery of gold in California in 1848, the rivers of the Central Valley and their floodplains were relatively unaffected by human intervention. Since then, many types of activities have collectively altered the rivers and floodplains and required establishment of the flood management system.

The Central Valley Prior to the Discovery of Gold

The Sacramento and the San Joaquin rivers historically meandered back and forth across the valley floor. The meandering rivers continuously eroded and deposited sediments, creating optimum conditions for habitat diversity. During winter storms and spring snowmelt, the Sacramento River overflowed its banks into several large low-lying basins that slowly drained back into the rivers or into Delta sloughs. The San Joaquin River waters spread into broad floodplains and wetlands adjacent to the river. Flooding of the basins and floodplains provided water storage that reduced the peak rate of flow to downstream areas, encouraged percolation into groundwater, and supported diverse riparian and extensive tule/emergent wetland communities.

Lush riparian forests once lined virtually every watercourse in the Central Valley.

A high species diversity and biological productivity in the Central Valley is reflected its mild Mediterranean climate and complex pattern of habitats. The floodplain supported an extensive belt of riparian woodland, willow thickets, freshwater marsh, wet meadows, grasslands, and oak savanna. Well-developed riparian systems occurred along virtually every watercourse in the valley. The San Joaquin Valley contained proportionally more wetland areas than riparian forests, whereas riparian forest dominated the Sacramento Valley. Floods were integral in shaping and sustaining riparian habitat and were part of the ecosystem process with which native aquatic and riparian species evolved.

The fertile floodplains of the Sacramento and San Joaquin rivers support a vast agricultural region of national and international importance.

Gold Mining and Agricultural Development

The California Gold Rush brought about the first large increase in Central Valley population, with some towns witnessing growth of thousands of people almost overnight. To aid the movement of people and supplies, riparian trees became the fuel of steam ships. Soon after 1850, the miners and settlers realized the agricultural possibilities of the rich alluvial floodplain soils in the Sacramento and San Joaquin River basins. They cleared forests and filled oxbow lakes and sloughs to plant orchards and field crops. They built levees to contain seasonal high flows and protect the new agricultural lands and growing communities from flooding. These activities began the creation of a highly-productive agricultural region; however, it had adverse effects on the ecosystem.

Artist's rendering of downtown Sacramento in the flood of 1850.

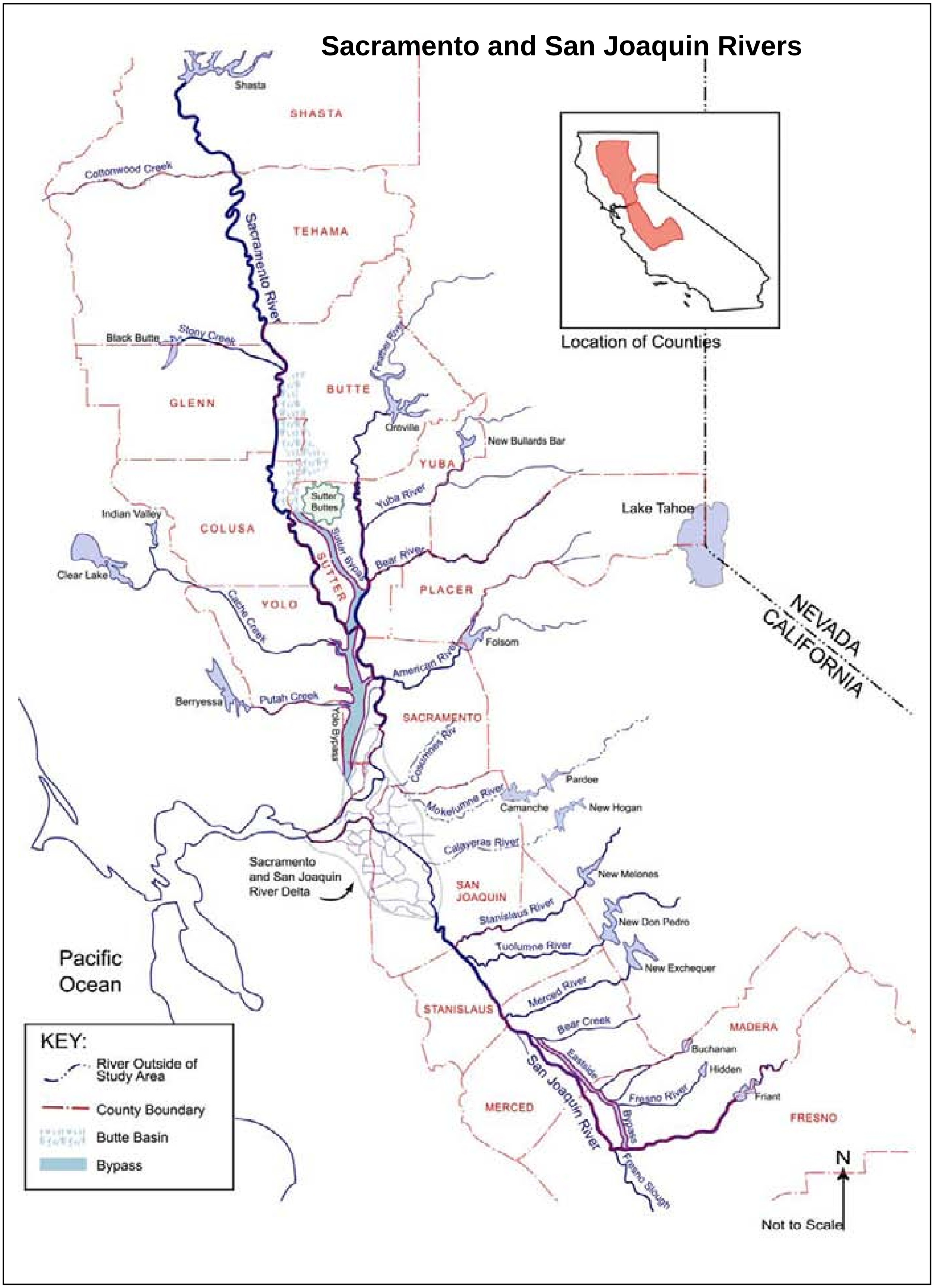
Landowners performed early levee construction in the Central Valley to address local flooding problems. They did not consider the hydraulic impacts on other areas, nor the natural processes of the rivers. In some cases, "levee wars" resulted, where settlers on opposite sides of the river alternately raised their levees to avoid flooding. The levees cut off areas of the floodplain, and its water storage capacity, causing flood flows to greatly exceed the capacity of the channels in many areas. Large storms during the 1850s and 1860s resulted in widespread flooding of farmlands and communities. Hydraulic mining between 1853 and 1884 worsened the flooding problems by washing away the sides of mountains and depositing millions of tons of silt, sand, and gravel into rivers and streams. These deposits raised the beds of the Sacramento, Feather, Yuba, Bear, and American rivers more than 20 feet in some areas. The river channels have since eroded through much of the deposited debris, but substantial quantities remain in some river reaches.

System-Wide Flood Conveyance

In the early 1900s, the Federal and State governments began construction of system-wide flood management facilities, including levees, weirs, and bypass channels. This included constructing new facilities and reconstructing existing private facilities to Federal engineering standards existing at that time. The effort in both river basins focused on protecting lives and property by increasing conveyance of floodwaters through the system. The design goal of the facilities was to aid navigation and flush sediment remaining from the earlier hydraulic mining. These conveyance facilities improved flood protection and navigation and allowed continued agricultural and urban development. They also constrained the river to specific alignments, significantly reducing channel meandering and further isolating the rivers from their historic floodplains.

Floodwater is diverted from the Sacramento River into the Yolo Bypass.

As urban and agricultural development within the floodplain increased, more communities and property were at risk of flooding. Improvements to the conveyance system were periodically made to meet local needs. This piecemeal approach to system repair and improvement often increased flooding risk in other areas while detracting from the function of the system as a whole.


Sacramento and San Joaquin Rivers
Location of Counties
SHASTA
TEHAMA
BUTTE
GLENN
YUBA
COLUSA
SUTTER
YOLO
PLACER
SACRAMENTO
SAN JOAQUIN
STANISLAUS
MERCED
MADERA
FRESNO
NEVADA
CALIFORNIA
Shasta
Cottonwood Creek
Sacramento River
Black Butte
Stony Creek
Feather River
Oroville
New Bullards Bar
Yuba River
Sutter Buttes
Sutter Bypass
Indian Valley
Clear Lake
Lake Tahoe
Bear River
Cache Creek
Folsom
American River
Berryessa
Putah Creek
Yolo Bypass
Cosumnes Riv
Pardee
Mokelumne River
Camanche
New Hogan
Calaveras River
Sacramento
and San Joaquin
River Delta
New Melones
Stanislaus River
New Don Pedro
Tuolumne River
New Exchequer
Merced River
Bear Creek
Eastside
Buchanan
Hidden
Fresno River
Friant
Bypass
San Joaquin River
Fresno Slough
Pacific
Ocean
KEY:
River Outside of Study Area
County Boundary
Butte Basin
Bypass
N
Not to Scale

The Corps constructed, and in many cases reconstructed, the Sacramento River Flood Control Project and the San Joaquin River Flood Control Project levees from already existing private levees. The non-Federal sponsor for the two major flood management projects in the Sacramento and San Joaquin River basins is The Reclamation Board, which has accepted the assurances of operating and maintaining the Federal projects under the authority of the Flood Control Act of 1944. In accordance with State law, most of the operation and maintenance responsibilities have been delegated to local districts.

The Sacramento River Flood Control Project was designed for rainfall storms with peak flows passing through the system for short periods of time. The San Joaquin River Flood Control Project was designed for both rainfall and snowmelt storms and thus considered longer duration peak flows resulting from snowmelt. In some cases, subsequent modifications to the system in both basins has resulted in the system passing high flows for longer periods of time, increasing the duration of stress on the levee system and the associated chance of levee failure due to saturation, erosion, sloughing, etc. The addition of dams, in particular, have increased the duration of high flows by capturing peak flood flows and releasing the water into the system in a controlled manner. While the operation of dams can increase the duration of stress on the levee system, dams significantly reduce the magnitude of peak flow for many flood events and prevent failure of the system.

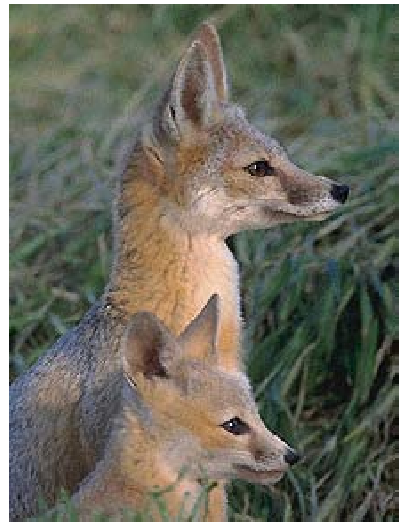
Water Supply and Flood Management Reservoirs

Although dams were used for water supply on small streams before the gold miners came to California, large-scale dam construction on the major rivers began in the 1930s and continued into the 1970s. Public and private reservoirs in the Sacramento and San Joaquin River basins have a combined gross storage capacity of about 20 million acre-feet. Dedicated flood storage in these reservoirs totals about 5 million acre-feet. The reservoirs substantially reduce seasonal high flows so the downstream flood conveyance system operates more safely and effectively. The Federal Central Valley Project (CVP) and the California State Water Project (SWP) are the largest Central Valley water projects, both exporting water south of the Delta through large pumping plants and canals. The CVP annually delivers about 7 million acre-feet of water for agriculture, urban, and wildlife use. The SWP provides supplemental water, about 3 million acre-feet annually, to approximately 22 million Californians and over 600,000 acres of irrigated farmland.

Shasta Reservoir on the Sacramento River is among dozens of flood regulation and water supply reservoirs in the Central Valley.

Reservoirs provide substantial flood management, water supply, and hydropower benefits. However, dams and water diversions have had a significant adverse affect on the health of the ecosystem. Dams have blocked access of anadromous fish to spawning areas, have reduced sediment transport, and have changed natural flow patterns, lowering the flows during wet periods and generally raising the flows during the drier part of the year. The lower flood flows, in combination with levee construction, have greatly reduced the extent of floodplain flooding and the associated spawning and rearing habitat for many native fish. Dams can also change water quality, adversely affecting aquatic species.

Diversions for water supply have reduced flow in the rivers, further decreasing the quality of riverine habitat and ecological processes. Substantially-reduced flows also have limited geomorphic processes and management of sediment that are essential to sustain riparian habitat in the long-term.



The San Joaquin Kit Fox is among 77 legally-protected plant and animal species in the Sacramento and San Joaquin River watersheds.

Environmental Awakening

Since the early 1970s, there has been a heightened awareness of how development can affect the environment and how degradation of the environment can impact our quality of life. Both the Federal and State governments require environmental documentation of new projects to identify potential adverse effects and associated mitigation. The National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) have played a major role in limiting additional environmental degradation. The Federal Clean Water Act and numerous State water quality laws and regulations help regulate water quality and development that could affect waterways and wetlands. Some of these laws have resulted in less water for agricultural and municipal and industrial water users and more water for water quality and the environment.

Within California, State and Federal laws protect many plants and animals. Many of these special status species inhabit the Sacramento and San Joaquin River basins. Listings of several species on the endangered species lists have resulted in increases in the cost of maintenance and operations of water resources projects by Federal, State, and local agencies.

The U.S. Fish and Wildlife Service and the National Marine Fisheries Service share responsibility for administering the **Federal Endangered Species Act** (FESA) (1973). This law provides protection for plants and animals listed or proposed for listing as "endangered" – in danger of becoming extinct – or "threatened" – likely to become endangered in the future. The **California Endangered Species Act** (CESA) (1977), administered by the Department of Fish and Game, provides similar protections. "Candidate" species are officially under review for addition to threatened or endangered species lists. "Species of concern" are monitored to ensure that their populations remain viable. All categories of species are collectively referred to as "special status species."

The increased environmental awareness is reflected in new programs and modifications of major government projects. In 1992, the Central Valley Project Improvement Act (CVPIA) modified the Central Valley Project (CVP) authorization to include "fish and wildlife" as a project purpose equal to water supply. The CVPIA required physical modifications to the project and dedicated some water supply for the protection, restoration, and enhancement of fish and wildlife. In 1995, eighteen State and Federal agencies (including the Corps and The Reclamation Board), with management or regulatory authority in the watershed of the San Francisco Bay/Sacramento-San Joaquin Delta estuary, joined together to form the CALFED

Bay-Delta Program. CALFED worked with California's environmental, urban, and agricultural communities to develop a plan to restore ecological health and improve water management for beneficial uses of the Bay-Delta system.   The CALFED Record of Decision (ROD) dated August 28, 2000, recognized that the Sacramento and San Joaquin River Basins Comprehensive Study overlaps the CALFED program and that changes to the flood management system are necessary to provide sufficient area and flow processes to support many CALFED riverine ecosystem objectives.

Some constraints limit the ability of the State and local levee districts to carry out prescribed operations and maintenance (O&M) activities, including clearing and sediment removal programs without substantial cost increases due to mitigation. Increased public concern for the environment and associated environmental laws have made it difficult to maintain the levee, channel, and bypass features of the existing flood management system as originally envisioned. As a result, many of the levees do not conform to their original design standards.

Conditions Today

Today, land use in the floodplains is principally agricultural and other open space, with the largest urban floodplain development in the Sacramento, Stockton, Fresno and Yuba City/Marysville metropolitan areas. The majority of the land is privately owned. The Central Valley produces about one quarter of the nation's food and provides major contributions to the economy of California and the nation. The existing flood management system has been a major supporting factor to the economic prosperity of the valley.

Flooding Problems

- Risk to life, health, and safety due to flooding.
- Damages due to flooding.
- Maintaining the flood management system is difficult and inconsistent.

The Central Valley is one of the fastest growing areas in the State. Much of this urban growth is located in flood-prone areas, placing people and property at increased risk of flooding. Areas subject to flooding include major transportation corridors that are critical to evacuation and emergency response during a flood.

The Central Valley is also a unique ecosystem, vital to the survival of numerous aquatic and terrestrial species. The health of this ecosystem continues to be threatened by the water management infrastructure and urban growth. Due to the constriction of river channels, water diversions, fragmentation and degradation of habitat, and the invasion of exotic species, the river system supports only a small portion of the natural processes and habitat essential for a healthy functioning ecosystem. The Sacramento and San Joaquin River basins support a variety of habitats including open water, seasonal and permanent wetland, vernal pool, riparian forest, grasslands and oak savanna. In addition, agricultural lands can contribute to ecosystem functions in many ways. They can support seasonal wetlands, provide foraging areas for wintering waterfowl, provide escape areas for terrestrial species during flood events, or provide floodplain habitat.

Levee breaks imperil lives and cause extensive damage to property and crops.

The Central Valley is the most vital waterfowl wintering area along the Pacific Flyway. Waterfowl and shorebirds forage primarily in natural and artificial wetlands and in agricultural lands. Both public and private land provides important nesting and feeding areas.

An often piecemeal approach to flood system improvements and floodplain management has caused uneven levels of system performance and unacceptable risks to public safety with changing land uses. System maintenance needs and ecosystem needs occurring in the same locations often delay repair work, leading to further flood system deterioration.

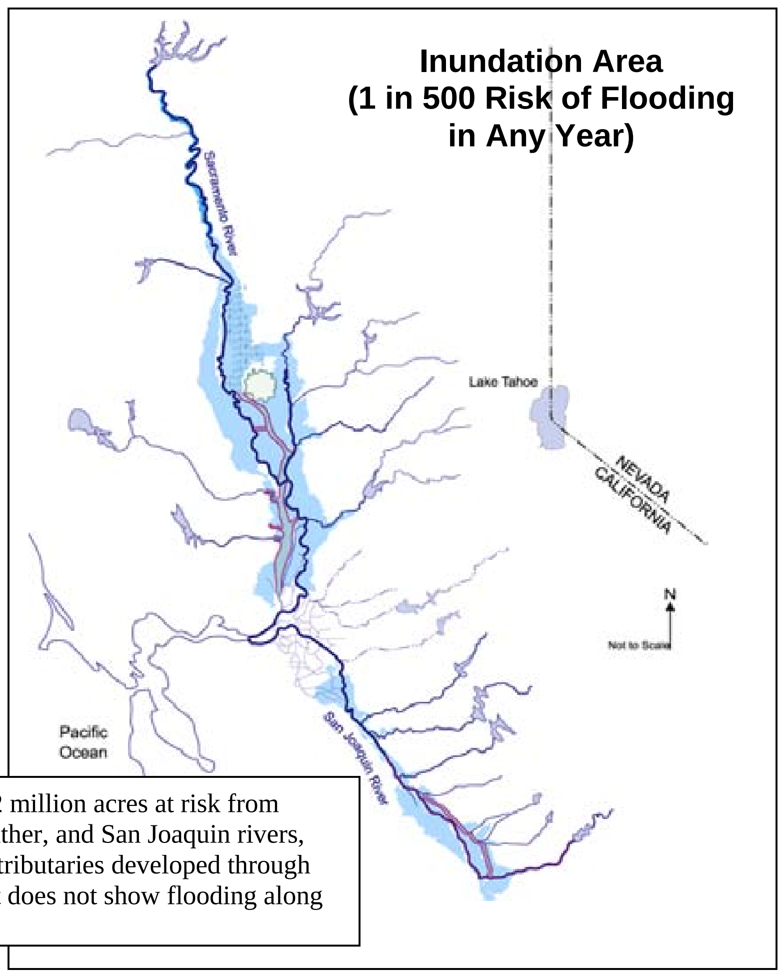
Ecosystem sustainability is being impacted by rapid changes in agriculture and increasing urbanization.

Federal Emergency Management Agency (FEMA) Floodplain Maps and Comprehensive Study Inundation Areas: How Are They Different?

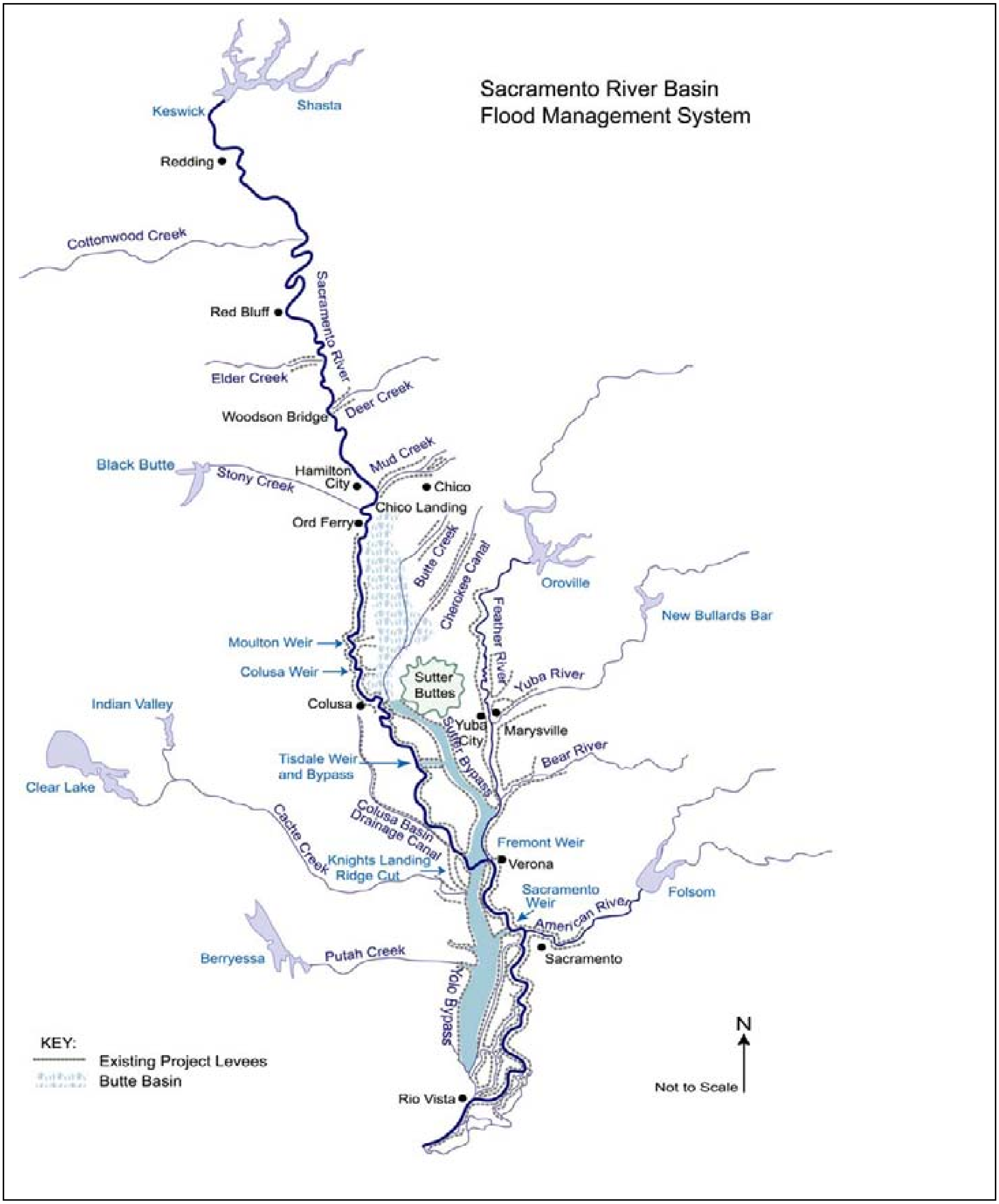
- The Comprehensive Study uses levee failure assumptions based on estimates of current levee reliability, whereas FEMA floodplain mapping assumes levees will not fail until their design water surface is exceeded. Consequently, in cases where stream water surface elevations are similar, FEMA maps may indicate a smaller area of inundation when compared with Comprehensive Study inundation maps.

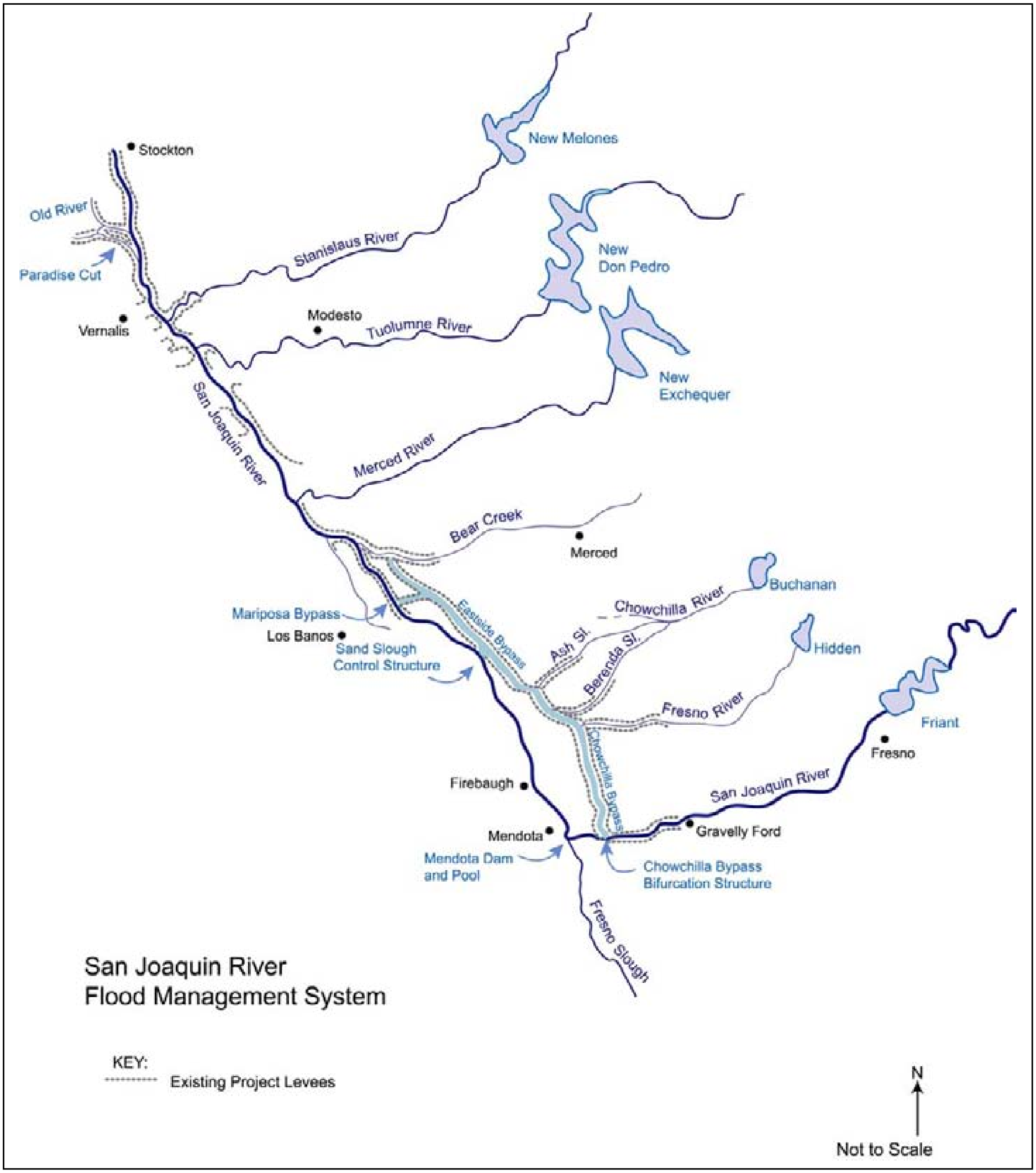
- The Comprehensive Study focuses on the performance of the flood management system as a whole and, as a result, inundation areas reflect the cumulative effect of levee failures as flood flows move through the system. As levee failures allow flood flows to escape from the channels, the amount of water in downstream reaches is decreased, potentially resulting in fewer levee breaks. In contrast, FEMA floodplains consider each levee break individually; levee breaks allow flood flows to escape from the channel for local assessment, but do not cause the river stage or assumed flow in the downstream channel to be lowered unless the levees are overtopped. In these cases, the different approaches will sometimes result in FEMA floodplain maps showing a larger area of inundation than the Comprehensive Study maps.

- FEMA's Flood Insurance Rate Maps (FIRMs) are used for flood insurance and floodplain management regulatory purposes. These maps are generally developed at a local scale, often with detailed topographic information, and include flooding from smaller, local streams. The intended use of the Comprehensive Study inundation maps is to evaluate the performance and inherent risk associated with the current and modified flood management systems under a range of hydrologic conditions. Comprehensive Study inundation areas are developed using system-wide modeling tools to identify flood-prone areas throughout the Central Valley and should only be used on a regional planning basis.



The map represents the more than 2 million acres at risk from flooding along the Sacramento, Feather, and San Joaquin rivers, and the lower reaches of the major tributaries developed through Comprehensive Study modeling. It does not show flooding along minor streams or in the Delta.


Sacramento River Basin
Flood Management System
Keswick
Shasta
Redding
Cottonwood Creek
Sacramento River
Red Bluff
Elder Creek
Deer Creek
Woodson Bridge
Black Butte
Stony Creek
Mud Creek
Hamilton City
Chico
Chico Landing
Ord Ferry
Butte Creek
Cherokee Canal
Oroville
Feather River
New Bullards Bar
Moulton Weir
Colusa Weir
Sutter Buttes
Yuba River
Indian Valley
Colusa
Yuba City
Marysville
Sutter Bypass
Bear River
Tisdale Weir and Bypass
Clear Lake
Cache Creek
Colusa Basin Drainage Canal
Fremont Weir
Verona
Knights Landing Ridge Cut
Sacramento Weir
American River
Folsom
Berryessa
Putah Creek
Sacramento
Yolo Bypass
N
KEY:
Existing Project Levees
Butte Basin
Not to Scale
Rio Vista



Stockton
New Melones
Old River
Paradise Cut
Stanislaus River
New Don Pedro
Modesto
Vernalis
Tuolumne River
New Exchequer
San Joaquin River
Merced River
Bear Creek
Merced
Buchanan
Chowchilla River
Mariposa Bypass
Los Banos
Sand Slough Control Structure
Eastside Bypass
Ash Sl.
Berenda Sl.
Hidden
Fresno River
Friant
Fresno
Chowchilla Bypass
Firebaugh
San Joaquin River
Mendota
Gravelly Ford
Mendota Dam and Pool
Chowchilla Bypass Bifurcation Structure
Fresno Slough
San Joaquin River Flood Management System
KEY:
Existing Project Levees
N
Not to Scale

The Sacramento and San Joaquin River basins have some unique features and characteristics. The Sacramento River basin typically receives the greatest runoff as a result of winter and spring rainfall. The Sacramento River is a perched river, where the river channel is at a higher elevation than the adjacent lower-lying basins. During major floods, the Sacramento River can produce peak flows over 10 times greater than the San Joaquin River. The design and construction of Sacramento River flood management facilities enable the river to operate as a continuous system from Ord Ferry, near the point of historical natural overflow to the adjacent basins, to the Delta. The Sacramento River flows combine with tides to strongly influence flood water levels in the Delta. This often causes backwater effects on the San Joaquin River in and near the Delta, causing sediment deposition.

Continuing Challenges

- Actual risk of levee failure is not commonly understood.
- Expected damages from flooding will rise as development continues in the floodplain.
- The existing flood management system cannot be maintained as originally intended because of ecosystem requirements, other resource conflicts, and institutional arrangements.
- Some people believe that ecosystem restoration and flood damage reduction are incompatible.

Between Lake Shasta and Red Bluff, the Sacramento River is relatively narrow and entrenched, with little floodplain and a narrow riparian corridor. Shasta Dam regulates most of the flood flows entering the reach, but unregulated tributaries add significant flood flows downstream from the dam. From Red Bluff to Chico Landing, the river is relatively free to erode and deposit bank material as it meanders within its floodplain. This reach does not have major levees or other flood management facilities and includes the most extensive riparian habitat of any reach of river. Downstream from Chico Landing, a system of levees, weirs, bypasses, and natural overbank areas convey flow to the Delta. Riparian habitat is confined to a much narrower corridor within the leveed reaches. Downstream from Colusa, riparian habitat is extremely limited by levees that are very close to the river. The Butte Basin is the most upstream overflow area. The Butte Basin flood relief structures generally overflow during a large flood after the downstream weirs are operating. The basin includes agricultural lands, sloughs, and wildlife refuges. Further downstream, the Sutter Bypass and finally the Yolo Bypass carry the bulk of flood flows to the Delta. Some riparian and wetland habitats exist in both bypasses. The Feather and American Rivers are major tributaries to the Sacramento River.

The Sacramento River basin occupies the northern portion of the Central Valley of California and the San Joaquin River basin is in the southern portion of the Central Valley. The topography of the Central Valley and surrounding terrain creates flood intensities unseen elsewhere in the nation. In his 1927 report to Congress, Major U.S. Grant III pointed out that the intensity of flood conditions in the Sacramento Valley are greater than any other American river system. In contrast to the Mississippi River, where the ratio of water to square foot of land available to take run-off was about 1.5, the ratio in the Sacramento Valley was 22. In an area subject to rapid flooding conditions, actions to improve flood forecasting and increase warning time should be continuously pursued.

Ecosystem Problems

- Lack of system-wide, dynamic, self-sustaining hydraulic and geomorphic processes.
- Reduction in the quantity, quality, diversity, and connectivity of riparian, wetland, floodplain and shaded riverine aquatic habitat.
- Low populations of many individual plant and animal species and their continuing decline.

Riparian forests in the Sacramento River basin are considerably smaller than they were historically, but still support a variety of wildlife. The vegetation includes Valley oak riparian, Great Valley cottonwood riparian, Great Valley mixed riparian elderberry savanna, oak woodland, freshwater marsh, seasonal wetlands, grasslands, and agricultural lands. Ecosystem functions, such as periodic inundation of habitat along the river, have also been reduced from the historical condition, resulting in a reduction of ecosystem diversity and productivity.

The San Joaquin River basin floods as a result of both rainfall and melting of the winter snowpack. The levee design of the San Joaquin flood management system protects discrete areas from flooding. These levees are discontinuous in places between Gravelly Ford and the Delta and in general, are more likely to fail than those on the Sacramento River, as evidenced by the 1997 floods.

Major tributary rivers from the western slope of the Sierra Nevada provide primary sources of water to the basin. Although the Kings River normally flows into the Tulare Basin, some water flows north to the San Joaquin River during major floods. West side tributaries provide only intermittent flows.

The San Joaquin River from Friant Dam to about Gravelly Ford is entrenched, with little floodplain and patches of remnant riverine habitat. The Eastside/Chowchilla Bypass and levee system begins downstream from Gravelly Ford and ends upstream from the Merced River. Much of this reach is essentially dry during portions of the year and supports sparse riparian habitat. From the Merced River to the Vernalis Gage, levees are discontinuous and in many cases were constructed to protect local areas. This part of the river still provides some fish and wildlife habitat. Special status vegetative communities along the San Joaquin River include some grasslands, northern hardpan vernal pools, Great Valley mixed riparian forest, and sycamore alluvial woodland.

The Reclamation Board is responsible for operation and maintenance of the Sacramento Flood Control Project and Lower San Joaquin River Flood Control Project. The Board has delegated much of this responsibility to local levee and reclamation districts, which were formed for this purpose. Environmental laws enacted since the projects were constructed have created additional requirements on the State and the districts that were not anticipated at the time of construction. The laws have forced a change in the methods used to maintain the system, adding to the time and expense involved in accomplishing system maintenance.

Because the flood control system has developed over time, there are at least four variations of the distribution of maintenance responsibilities; 1) maintenance performed by the Department of Water Resources (DWR) under California Water Code # 8361 funded by the General Fund; 2) maintenance funded by local landowners, but performed by DWR in Maintenance Areas or MAs, 3) maintenance performed by local landowners without formal districts and 4) the most common, maintenance by local levee, maintenance or reclamation districts set up by the California legislature. Currently, there are more than eighty maintenance agencies, each with responsibility for its portion of a levee. The majority of maintenance costs are paid by local entities.

Since 1960, The Reclamation Board and the Corps have jointly worked together on the Sacramento River Bank Protection Project to reduce erosion damage to levees. During major floods, several governmental and non-public agencies respond with assistance in flood fighting and in emergency repair and post-flood cleanup. Public Law 84-99 provides for emergency assistance in areas where project and non-project levees meet minimum requirements.

After the flooding in 1986, Congress authorized the Corps to evaluate the condition of the Sacramento River Flood Control System. Specifically, the Corps determined the remedial work needed to bring the system into compliance with its design standards. The Corps completed the evaluation in five phases, each represented by a different geographical area. Phase I – Sacramento Urban Area – has been completed. The remaining phases – Marysville/Yuba City Area, Mid-Valley Area, Lower Sacramento Area, and the Upper Sacramento Area – are in progress. Rehabilitation will occur only in locations where the flood damage reduction benefit exceeds the repair costs.

Central Valley wetland areas are an integral part of the Pacific Flyway.

Many ecosystem restoration activities in the Sacramento and San Joaquin River basins are currently underway or planned. While a system-wide vision guides many of these activities, many are small in scale or local in scope and sometimes conducted only as opportunities arise. Although many of these efforts are small, fish and wildlife are beginning to benefit. Some anadromous fish spawning runs appear to be responding to better flows, habitat, and reduced stressors. Restoration of wetlands, modified agricultural practices, and expanded refuges have improved conditions for waterfowl along the Pacific Flyway.

According to the U.S. Fish and Wildlife Service and National Marine Fisheries Service lists and the California Department of Fish and Game Natural Diversity Database, the combined total of all "special status species" potentially occurring in the study area is 378. Seventy-seven of these species are listed under FESA and CESA. The exact locations and numbers would require detailed biological field inventories.

In an effort to reduce the impacts of flooding through better coordination of floodplain management, Assembly Bill 1147, signed into law in 2001 by Governor Davis, recommended establishment of a Floodplain Task Force. The California Floodplain Management Task Force was established in early 2002 to examine specific issues related to State and local floodplain management. The Task Force, a diverse group of private, non-profit, and local interest groups and State, Federal, and local agencies, has created over 30 recommendation for improved floodplain management.

What Can We Expect in the Future Without the Comprehensive Plan?

Projections show that California's population will increase by more than 15 million in the next 20 years, primarily with much of this increase located in the current and planned urban areas of the Central Valley. The population increase will result in profound changes in land use in the Central Valley, increasing the population at risk from flooding and further reducing existing agriculture and wildlife habitat. These changes will most likely occur as an encroachment of present urban/ suburban areas into adjoining farmland. In addition to placing more people and damageable property at risk of flooding, such urbanization affects the flood management system by increasing impermeable surfaces, increasing flood peak flows and volumes, reducing floodplain storage, reducing groundwater recharge, and increasing non-point pollution from runoff. Continued urban development within the floodplain will make future changes to the "footprint" of the flood management system increasingly more costly.

The conversion of agricultural lands to other uses is expected to continue as urban areas grow and price fluctuations in agricultural markets affect the profitability of agricultural operations. This conversion reflects not only the growth of high density, urban land uses, but also the movement of prospective homeowners moving farther away in search of lower housing costs and a more rural lifestyle. These factors are taking land out of production, which in turn reduces the economic viability of the larger agricultural service industry.

Conservation efforts by CALFED, the Natural Resources Conservation Service, the California Department of Food and Agriculture, and other public and private programs are underway to restore ecosystem values, protect open space, and preserve agricultural land uses. These voluntary programs provide opportunities for landowners to accommodate changing economic conditions, rather than converting farmland to more intensive land uses. Due to the present configuration of the flood system and the potential to increase flood damages, many of the actions contemplated in the CALFED Ecosystem Restoration Program (ERP) can only be accomplished with changes to the flood system.

Trends indicate that further incremental system modifications will become increasingly difficult.

- Flood management projects will be subject to increasingly costly hydraulic and environmental mitigation requirements.
- Ecosystem restoration projects will need to demonstrate that they do not result in hydraulic effects or reduce public safety.

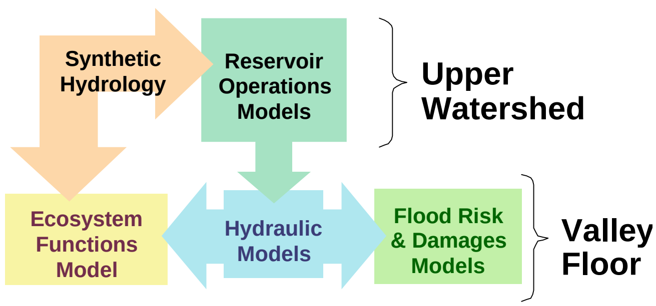
Levee maintenance has grown more difficult and expensive due to such factors as poor levee foundations, erosion, and conflicts with environmental concerns. The levees will continue to deteriorate, increasing the flood risk, especially in rural areas. As a result, emergency flood response work will become more expensive. Without a visionary Comprehensive Plan, there is a risk that flood management projects completed in the future will provide only local benefits and could transfer flood risk to other areas.

Opportunities for comprehensive system-wide floodplain management and ecosystem restoration will decrease with time unless immediate work begins under the Comprehensive Plan.

Guide to Technical Studies

The Comprehensive Study developed a suite of system-wide evaluation tools to gain a better understanding of the complex hydrologic, hydraulic, and ecologic processes that interact in the rivers and floodplains of the Sacramento and San Joaquin River basins. Prior to the Comprehensive Study, no models existed that evaluated Central Valley river systems on a watershed scale. The shear size of the study area warranted a new technical approach. The technical tools that were developed encompass the entire river systems, from reservoirs in the upper watersheds downstream to the Delta. They provide an unprecedented capability to evaluate the operation of the existing flood management system and develop future projects to reduce flood damages and improve the environment.

The technical tools consist of computer models and an extensive information database that allow a system-wide approach essential to future project planning. Rather than focusing on localized areas, the tools allow tracking the effects of potential projects throughout the river system. The study team used the tools to perform analyses of the existing system and evaluate an array of "what if" scenarios brought forth by participating agencies and stakeholders. The tools are a valuable resource for future studies.

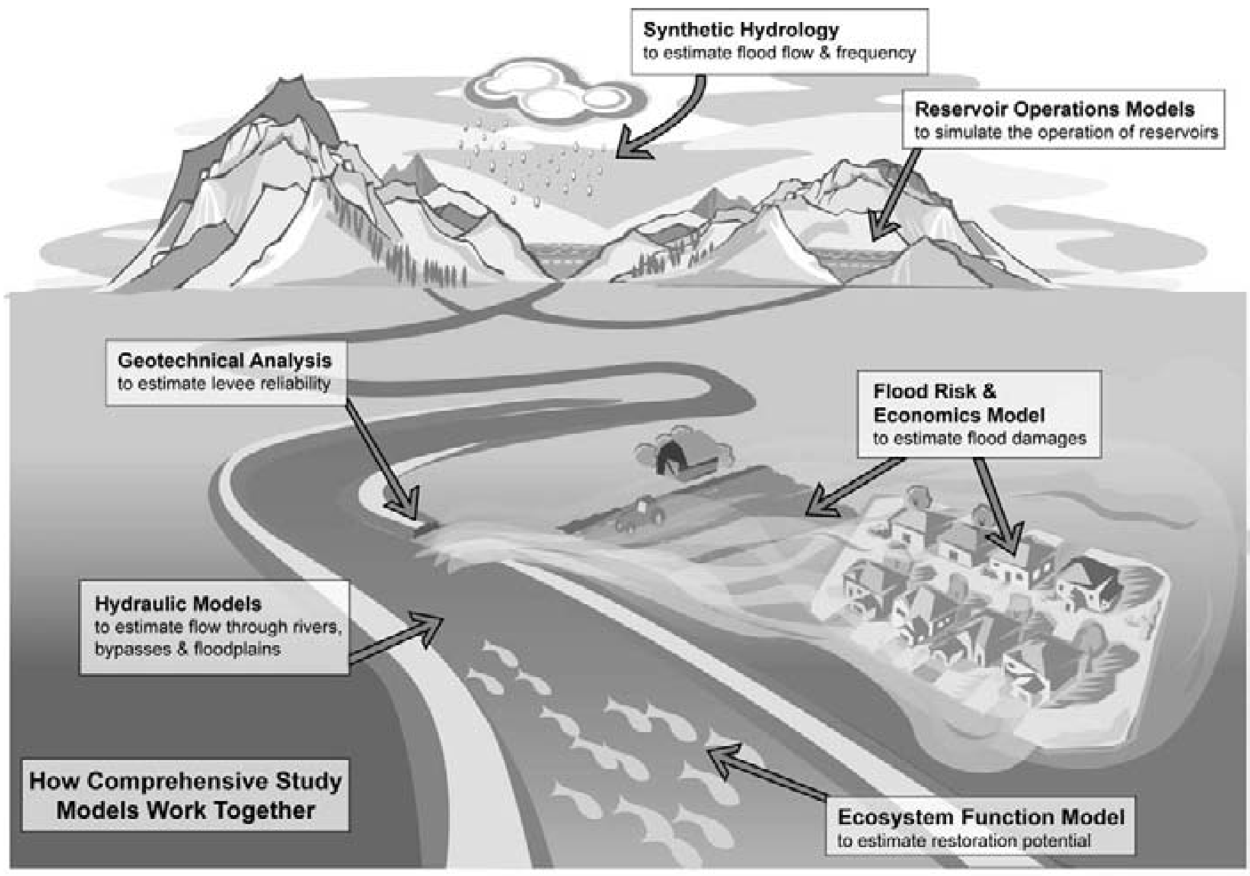


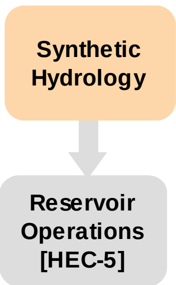
Central Valley Watershed Evaluation Tools

Discipline	Technical Product	Purpose / Description
Surveys and Mapping	Topography Digital Terrain Models Aerial Photographs	Mapping along the river corridors of the Sacramento and San Joaquin rivers, their major tributaries, and bypass systems, in digital format for use in a CAD (computer aided design) or GIS environment.
Hydrology	Unregulated Hydrology	Basin-wide synthetic flood hydrology for multiple flood conditions, including events with a 50%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% chance of occurring in any year.
	HEC-5 Models	Simulate the operation of over 70 headwater and foothill reservoirs tributary to the Sacramento and San Joaquin rivers.
Hydraulics	UNET Models	Simulate river system hydraulics along over 1,000 miles of Central Valley rivers, flood bypasses, and other major waterways.
	FLO-2D Models	Simulate the movement of water through valley floodplains.
	DSM2 (Delta Simulation Model 2)	Evaluate flood conditions in the Delta.
Geotechnical	Levee Reliability Evaluation	Information about the reliability of levees within the Sacramento and San Joaquin River basins.
Flood Damage Analysis	HEC-FDA (Flood Damage Analysis)	Evaluate flood risk and economic damages in the Central Valley, incorporating risk analysis
Ecosystem	EFM (Ecosystem Functions Model)	Evaluate functional relationships between hydrology/hydraulics, and riparian, wetland, and riverine habitats.
Information Management	GIS (Geographic Information System)	Geographic database of the Sacramento and San Joaquin River basins (including hydrography, habitat, development and infrastructure, flood management facilities, properties, levee alignments, geology, and much more).

The technical tools developed for the study can be used either individually or together to evaluate existing conditions or test the response of the flood management system to potential modifications. Model output and other information are passed from one model to the next, starting with hydrology and reservoir operations in the upper watersheds, moving downstream to the rivers and floodplains of the valley floor, and into the Delta.

There is a separate document entitled, “Technical Studies Documentation/Summary of Technical Studies” which has 7 appendices. The separate document with appendices is not a part of this report. Work on the appendices, which includes various models, will continue beyond the publication and distribution of this Interim Report. Planning for local or regional projects will provide the opportunity for updating the existing models or developing new models as needed. The tools and models of the appendices will not be used until they are updated considering the best available information, including information based on the expertise and experience of local stakeholders.





Synthetic Flood Hydrology

Flood hydrology describes the magnitude, timing, distribution, and frequency of floods. Floods in the Sacramento and San Joaquin River basins typically result from heavy rainfall or combined rainfall and snowmelt in the mountains and foothills, which flows through an extensive system of reservoirs before reaching the valley floor. Two tools were developed to simulate the foothill and upper watershed portion of the river system: hydrology to characterize the amount of stream flow generated by storms, and reservoir operations models to simulate the role of reservoirs in managing flood flows.

The Comprehensive Study developed synthetic, unregulated hydrology for seven flood events: those with a 50%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% chance of occurring in any year. In general, the hydrology is termed 'synthetic' because the 30-day flood hydrographs are based on flows and volumes observed in historic floods, but are not exact replicas of historic events. The hydrology is termed 'unregulated' because it does not reflect the influence of reservoirs, which significantly alter flood flows entering the valley. In total, the study created over 13,000 unregulated hydrographs for the seven flood frequencies at over 50 locations.

The hydrology is unique because it acknowledges that floods are created by varying storm conditions throughout the basins – heavy rainfall at one end of the valley doesn't necessarily mean heavy rain elsewhere. Historic storm patterns across California provided representative storm centerings to simulate floods involving multiple tributaries and reflect the influence of the

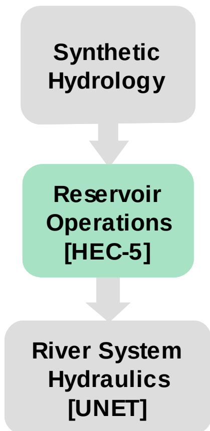
How Often do Floods Happen?

Flood risk is described in many different ways. It is traditional to describe flood risk in terms of a level of protection, such as "100-year level of protection." However, this simplification can be misleading and is often misinterpreted as meaning that flooding will occur only once during the specified number of years. Level-of-protection estimates are based on the average interval between failures of a flood prevention system, such as a levee. A 100-year level of protection means that on average, over a very long period of time (such as thousands of years), flooding would happen about once every one hundred years. But during that time, the actual spacing between 100-year floods could be much shorter or longer than 100 years. For example, during a recent 10-year period, two large storm events resulted in flows that approached the 100-year level on the American River.

Other statistical terms can be used to more accurately describe flood risk. Two examples are provided in the table below with comparable return frequency terminology. These and other flood risk statistics can be estimated by the Corps' risk analysis model, HEC-FDA. Although these terms are cumbersome and can be difficult to understand, they allow a more complete and accurate description of flood risk than level of protection or return frequency.

Probability of Occurrence or Exceedence The probability that a flood of this magnitude will occur (or be exceeded) in any year, expressed as a statistical chance or percent probability		**Level of Protection (Return Frequency in Years)** The period of time between flood events of this magnitude, averaged over many (thousands) of years
1 in 2	50%	2
1 in 10	10%	10
1 in 25	4%	25
1 in 50	2%	50
1 in 100	1%	100
1 in 200	0.5%	200
1 in 500	0.2%	500
1 in 1000	0.1%	1000

coastal and Sierra Nevada mountain ranges. Twenty-seven different storm centerings, stressing both tributaries and the main stems of the Sacramento and San Joaquin rivers, emulate the diverse spectrum of floods that can affect the Central Valley.

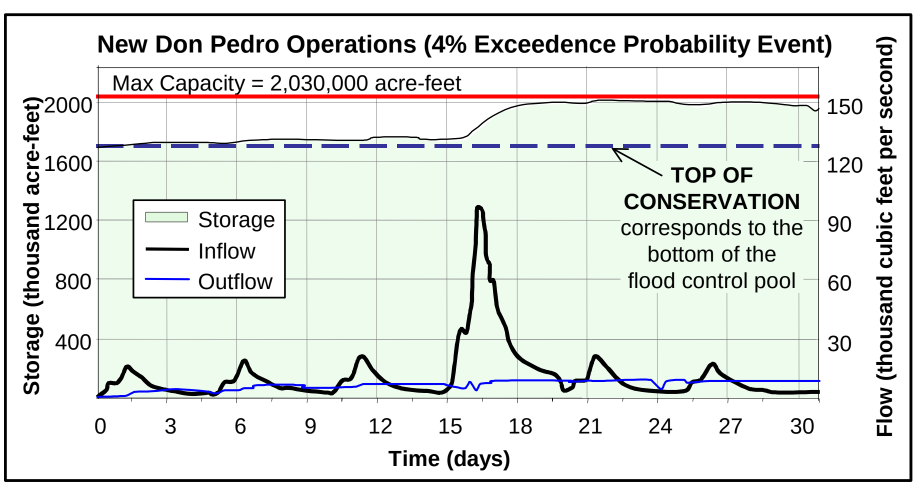


Reservoir Operations Models

Because the synthetic hydrology does not reflect the operation of the numerous reservoirs in the Sacramento and San Joaquin basins, the study developed computer models to simulate reservoir storage and release operations during flood events. The Corps' HEC-5 computer program simulates over 70 flood control, water supply, and multipurpose reservoirs that are currently operated for flood management or have an active storage space greater than 10,000 acre-feet. Due to the large number of reservoirs, the study developed two separate HEC-5 models in each basin, one for the smaller, but more numerous headwater reservoirs, and another for the larger foothill reservoirs. The San Joaquin HEC-5 models simulate 17 headwater reservoirs and 19 foothill reservoirs tributary to the San Joaquin River, while the Sacramento HEC-5 models simulate 27 headwater reservoirs and 9 foothill reservoirs. These models represent the largest known application of HEC-5 and are the most inclusive source of information on the operation of reservoirs tributary to the Central Valley.

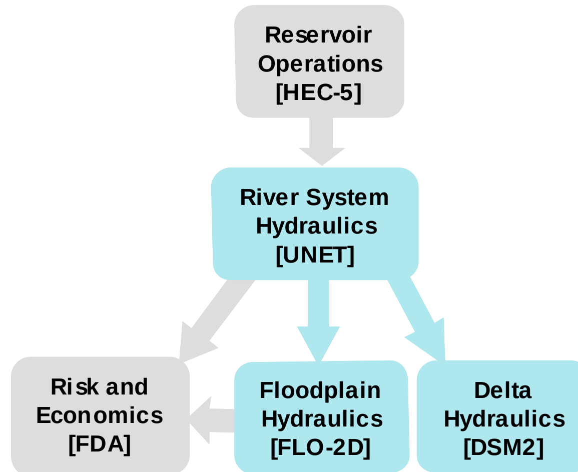
The HEC-5 models reflect mandatory, "by the book" operations established in the Water Control Manual for each flood control reservoir. These manuals define the operational rules and release criteria that must be followed by reservoir operators during the flood season. For reservoirs that do not have formalized flood operations or published criteria, operational criteria were developed through discussions with facility owners and operators and by analyzing historic gage data. However, historic reservoir operations may deviate somewhat from the HEC-5 simulations because severe floods sometimes dictate deviations from established operational criteria.

The unregulated hydrographs are used as input to the headwater reservoir models. Some foothill reservoirs have agreements with upstream reservoirs whereby they can be credited for unused storage space. Credit space is determined then results from the headwater reservoirs are used as input to the foothill reservoir models. The result is regulated flood flows downstream from the foothill flood management reservoirs. The regulated hydrographs are then used as input to the hydraulic models that simulate flood flows in the valley.



The adjacent figure is an example of a flood routing through New Don Pedro Reservoir during a flood event with a 4% chance of occurring in any year (1-in-25 chance), under existing conditions. As shown, the reservoir fills to near capacity, but maintains low releases during peak inflows.

River System and Floodplain Hydraulic Models



Hydraulic models simulate the complex network of rivers and channels that flow out of the foothills and through the Central Valley, eventually entering the Delta. The Comprehensive Study's modeling approach differs from the traditional approach in which rivers or reaches are examined individually. The study's models compute water surface elevation, discharge, average velocities, flooding extent, and track flood volume changes as a flood moves through the river system. An extensive data collection effort provided up-to-date topographic and bathymetric (in-channel) data necessary to develop these models. The study developed aerial photography, contour mapping, and digital terrain models along the river corridors of the Sacramento and San Joaquin rivers, their major tributaries, and bypass systems.

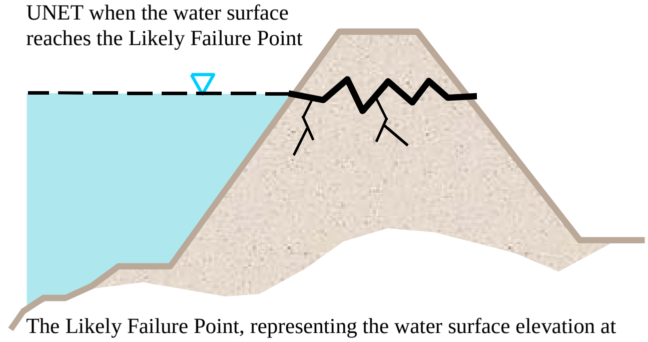
Two computer models are used jointly to simulate channel and overbank hydraulics in the Sacramento and San Joaquin River systems. Flows within the river channels and bypasses are simulated using the UNET model, and the movement of water in the floodplains (after it has escaped the river channel) is simulated with the FLO-2D model. The study used a third model, the Delta Simulation Model 2 (DSM2), to estimate flood conditions in the Delta.

River System Hydraulic Models

The UNET computer model simulates unsteady flow (flow that changes over time) through the river channels, weirs, bypasses, and storage areas of the Sacramento and San Joaquin River basins. The study developed separate UNET models for the Sacramento River and the San Joaquin River systems, starting downstream from the major flood control reservoirs and terminating at the Delta. In general, model construction consisted of collecting and processing extensive topographic data, developing river channel alignments, developing cross-sectional geometry, and including structures that affect flows (bridges, levees, weirs, etc). Channel geometry is simulated in the models by cross sections spaced at approximately $^{1}/_{4}$-mile increments. Overall, the UNET models simulate over 1,000 miles of Central Valley waterways.

The regulated hydrology, in the form of 30-day flood hydrographs for each of the seven frequency floods and various storm centerings, provides input for the UNET models. Downstream boundary conditions in the Delta reflect tidal and estuary influences. The UNET models simulate levee failures, storage interactions with adjacent overflow basins, weirs and overflow structures, and bridges. The UNET models represent vegetation and other channel obstructions by varying channel roughness coefficients.

In order to understand what potential damage could occur from flooding, the study team devised a levee failure methodology to determine when simulated flows would cause levees to fail and a floodplain to be formed. The methodology provides a conservative estimate of potential flooding extent for system-wide hydraulic and economic evaluations. To ensure that all potential economic damages are accounted for, the failure approach reflects a worst-case condition without flood fighting or other emergency actions. Levee failure is initiated in UNET when the simulated water surface elevation reaches the likely failure elevation for a given levee, defined as the stage at which there is a 50% chance of levee failure. Flow through levee breaches is then passed to the FLO-2D floodplain model.



The Likely Failure Point, representing the water surface elevation at which there is a 50% chance of levee failure, was determined reach-by-reach based on available geotechnical data, extensive interviews with levee district personnel, past levee performance, and engineering judgement.

The levee failure methodology can significantly influence simulated flood flows. It does not represent conditions that would occur during an actual flood event, when flood fighting and other emergency actions would take place and fewer failures are likely to occur. In some cases, the cumulative effect of multiple upstream failures simulated in UNET can reduce the volume of flow in downstream reaches, or large breaches can produce pronounced reductions in water stage. Consequently, this levee failure approach may not be appropriate for every model application. In addition, the models do not account for sediment movement, scour, or deposition; they assume no exchange with groundwater; and they do not simulate water temperature. The model calibration used historic flood events (1995 and 1997 floods); as such, they may not be accurate simulating low flows. The spacing of cross sections in the UNET models (typically between $^1/_5$- and $^1/_4$-mile) may preclude the direct application of the models to studies requiring more detail or evaluating localized hydraulic conditions.

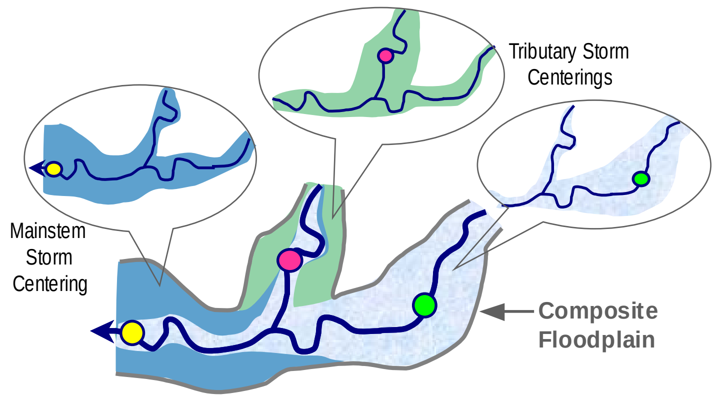
The UNET models generate a tremendous amount of information, including flow, stage, velocity, and other hydraulic parameters at every cross section. Model output produced data to develop stage-frequency and discharge-frequency relationships at key index points for subsequent use in the flood risk and damages model.

Floodplain Hydraulic Models

The study team selected the FLO-2D model to simulate floodwater that has broken out of the river channel and is moving across the topography of the valley floodplain. Simulated UNET out-of-bank flows from overtopping or levee failure are the input to FLO-2D. Because out-of-bank flows are more common in the San Joaquin Basin, the FLO-2D models cover nearly the entire basin, whereas the FLO-2D models in the Sacramento Basin primarily cover the major historic overflow basins.

Unlike the channel cross sections used in UNET, topography is represented in FLO-2D as a two-dimensional grid network developed from U.S. Geological Survey (USGS) 30-meter digital elevation data. Due to the considerable size of the FLO-2D models, grid sizes are relatively large - about 2,000 feet on edge. Bridges, streets, and other features are not specifically modeled in FLO-2D, but raised highways, levees, and other topographic features are captured by the grid elements.

The FLO-2D model predicts how water moves through the floodplain, calculates its depth, and estimates the extent of flooding. The study team used inundation areas resulting from multiple storm centerings to delineate a single 'composite floodplain' for various flood frequencies. It is important to note that these are not FEMA floodplain maps, nor are they intended to replace or supersede existing FEMA maps. The composite floodplains areas provide input to the flood risk and economic damages model.



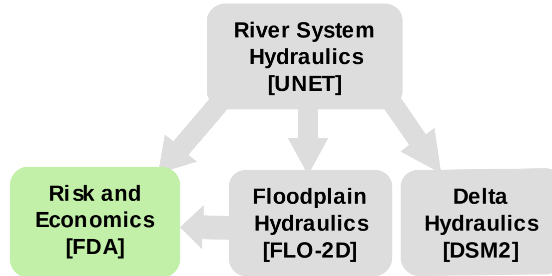
The 'Composite Floodplain' concept recognizes that a floodplain is not created by a single flood event, but by a combination of flows from different storm events on the various tributaries – each shaping the floodplain at different locations. Each storm centering produces a different component of the composite floodplain, capturing the full extent of inundation possible.

Delta Simulation Model

The study team adopted the DWR's DSM2 model to evaluate the effects of potential projects on flows and stages in the Delta. The Delta is a very complex hydraulic system influenced by tides, tributary inflows, water supply pumping, and many other factors.

DWR originally created DSM2 to evaluate water quality within the Delta under low-flow conditions. The study team re-calibrated the model to simulate floods. The study team truncated the DSM2 model such that DSM2 flow input locations coincide with the downstream limits of the UNET models, facilitating handoff of data between the two models. Output from the DSM2 model includes stage, flow, and storage volume data. The DSM2 model is not capable of simulating levee failure and does not take into account the extended high stages that often occur in the Delta and can affect levee stability. DSM2 input includes inflows provided by the UNET models and flood flows from other Delta tributaries, such as the Mokelumne and Calaveras rivers. The model helps in understanding existing flood conditions in the Delta and can evaluate the effects of potential changes to Delta inflows or channels.

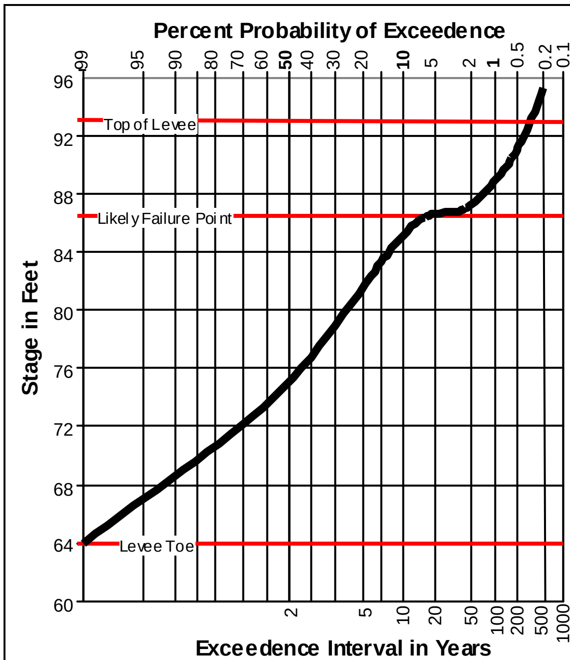
Flood Risk and Economic Damages Model



The Comprehensive Study used the Corps' Flood Damage Assessment (HEC-FDA) computer model to estimate economic damages resulting from floods and quantify the risk of flooding. HEC-FDA uses input from the UNET and FLO-2D models, along with geotechnical data and information on land use, property value, and other floodplain attributes. HEC-FDA expresses flood damages as Expected Annual Damages (EAD), a single, annualized measure of the damages that could be caused by a full range of possible flood events. HEC-FDA calculates flood risk in three ways: the expected probability of flooding in any given year, the long-term risk of flooding over a specific time period, and the probability of successfully passing specific flood events.

Risk Analysis is an approach used in Corps flood management studies based on statistical techniques to characterize the performance of a proposed project. There are numerous uncertainties associated with flood damage reduction studies, related to both natural systems (variations in climate, stream flow, river stage) and engineered systems (reliability of levees, floodgates). Risk Analysis recognizes that the information used in a flood damage analysis is not perfect. For example, many years of historic stream gage data may not be available to develop the hydrology, or the models used to simulate reservoir operations may deviate somewhat from actual operations. Unseen features, such as cracks hidden within the levee, could influence the performance of a levee. Similarly, economic damage figures rely on the best estimates of structure locations and values, flood duration, the crops grown on farmland, and other variables.

HEC-FDA allows users to assign uncertainty "error bands" to hydrologic, hydraulic, geotechnical, and economic input. The program calculates economic damages and flood risk thousands of times using values that are randomly picked within these error bands. The result is a range of possible answers, with some answers having been calculated more often. For example, HEC-FDA calculations might determine that the range of potential annual flood damages for a project is somewhere between $5- and $45-million dollars; but the value that was calculated most often - the Expected Annual Damage - is $35-million. Based on a series of similar statistical calculations, HEC-FDA might estimate that a project has a 68% chance of safely containing the 1% flood, or that a particular area has a 15% chance of flooding during a 25-year period. HEC-FDA can be applied to existing and with-project conditions to determine economic benefits or estimate the reduction in flood risk.



Hydraulic input to HEC-FDA includes stage-frequency curves developed at the index points from UNET model simulations.

Because there are over 2.2 million acres potentially at risk of flooding in the Central Valley, floodplains were divided into smaller impact areas to facilitate the HEC-FDA analysis. The impact areas were delineated based primarily upon flooding characteristics (sources and flow patterns) and the underlying land uses. The outermost extent of the impact areas is based upon the 0.2% (1-in-500) floodplain. There are 68 impact areas in the Sacramento River Basin and 42 impact areas in the San Joaquin River Basin. One index point along a river channel is assigned to each impact area, providing a location to pass flood stage and flow frequency information from the hydraulic models to HEC-FDA.

> **Risks**
>
> The economic analysis includes an inventory of over 2 million acres of floodplain with about 600,000 people at risk of flooding, about 196,000 structures valued at about $47 billion, and croplands with annual production of $1.8 billion.

Economic Damages

The economic analysis component of HEC-FDA utilizes a variety of information about each impact area:

- Flood inundation extent and depth for events with a 2%, 1%, 0.5%, and 0.2% chance of occurrence.
- Characteristics of various flood damage categories, such as residential, industrial, and farmsteads.
- Land use, crop types, and inventories of structures in each damage area.
- Estimated values of structures and their contents, based primarily on county assessor data.
- Relationships between flood depth and property damage, for both urban and agricultural areas.

The study team calculated EAD valley-wide for existing conditions. HEC-FDA can also evaluate proposed projects, establish economic benefits, and be used to perform cost-benefit analyses.

Flood Risk

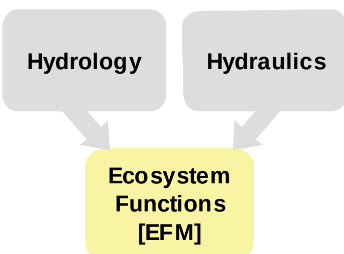
The flood risk component of HEC-FDA uses input from the hydrology, hydraulic models, and levee stability analysis to estimate the likelihood of flooding. The risk of flooding is reported by HEC-FDA in three ways:

- **Annual Exceedance Probability -** the likelihood that an area will be flooded in any given year, considering the full range of floods that can occur and all sources of uncertainty.

- **Long Term Risk -** the probability that damages will occur during a specified timeframe, reported for 10-year, 25-year, and 50-year periods. For example, a value of 0.850 for the 25-year reporting period reflects an 85% chance of flooding during a 25-year period.

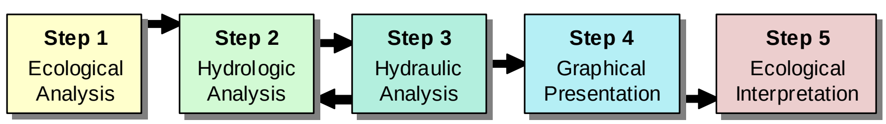
- **Conditional Non-Exceedance Probability** - the probability of safely containing a flood with a known frequency, reported for the 10%, 4%, 2%, 1%, 0.5%, and 0.2% floods. For example, a conditional non-exceedance probability of 0.900 for the 1% flood indicates a 90% probability that the system will be able to contain the 1% flood event without failure.

Although the flood risk outputs may seem similar, they each describe a different aspect of flood risk. Annual exceedance probability accumulates all uncertainties into a single risk value, whereas conditional non-exceedance probability depends upon the severity of the flood event. While annual exceedance probability describes the likelihood that flooding *will occur*, conditional non-exceedance probability describes the likelihood that flooding *will not occur* during a given year. Project performance statistics were used to evaluate several of the basin-wide scenarios, and can be used to evaluate the performance of potential modifications to the existing systems. Together, they provide a more complete description of flood risk than can be conveyed by traditional return frequency terminology.



Ecosystem Functions Model

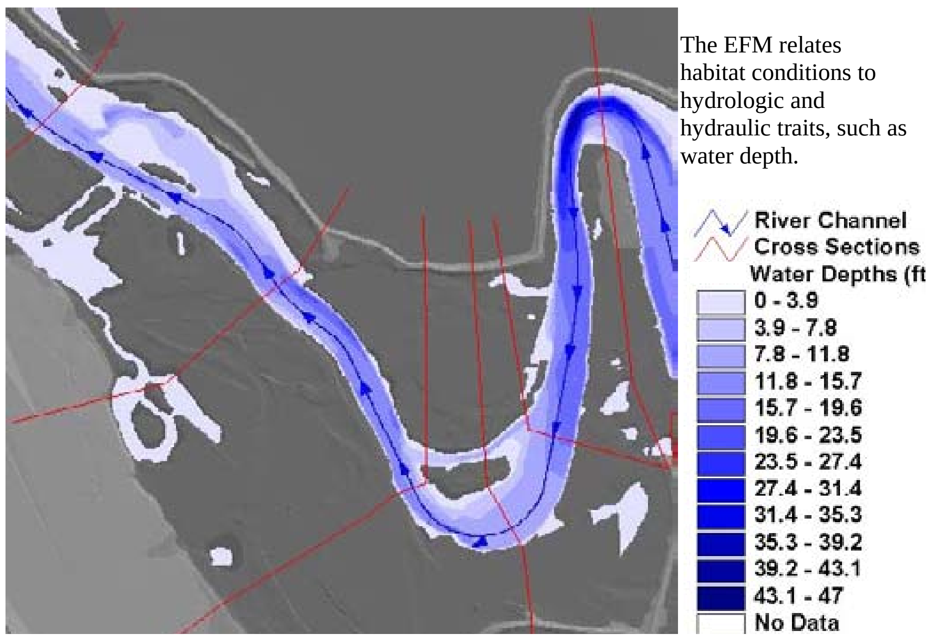
The Comprehensive Study developed the Ecosystem Functions Model (EFM) to help predict differences between existing and potential with-project conditions in river reaches that would be affected by changes to the flow regime or physical changes to the floodway. Using input variables such as stream flow, land use, soil type, vegetation, and topography, the model provides an evaluation of how potential projects might change conditions that are favorable to various types of habitat. The EFM differs from other tools in the Comprehensive Study modeling suite in that it is applied on a reach-by-reach basis rather than to the entire watershed. In addition, the EFM is not a single computer program, but rather a series of analyses that are interpreted by ecologists to predict a biological response. The five major steps in the EFM are described below:



Step 1 - Ecological Analysis. The ecological analysis step identifies biological relationships between river hydrologic and hydraulic conditions and the riverine ecosystem. These relationships reflect the different stream flow duration, flow frequency, and stage recession requirements of different types of habitats. The ecological analysis has identified fifteen biological relationships to date, but others may be developed and added to the EFM in the future. Twelve of these relationships require hydrologic and hydraulic information developed in Steps 2 and 3. The ecological analysis addresses two major elements: the aquatic ecosystem and the terrestrial ecosystem.

The aquatic relationships focus on factors that affect the life stages of salmonids and Sacramento splittail, which are used as representatives of the entire aquatic community. In-channel aquatic relationships examine the dependence of suitable streambed materials, instream cover, and bank vegetation on changes in flow and river morphology. Aquatic floodplain relationships identify overbank flow conditions that benefit floodplain spawning and rearing. The terrestrial ecosystem element evaluates existing riparian and wetland zones, rates of ecosystem change in these communities, and associated wildlife habitat values. Changes in riparian/wetland habitat are predicted by overlying maps of various attributes – such as inundation frequency, depth, or extent - that relate to terrestrial ecosystem health and development.

Step 2 - Hydrologic Analysis. A statistical analysis translates the ecosystem relationships developed in Step 1 into discharges (stream flows) for specified durations, flow frequencies, and stage recession rates. The statistical analysis uses historical, existing, and potential with-project conditions that result from modified reservoir operations, changes to levees, or other modifications that could be considered. Because there is no existing computer software package that meets the needs of the EFM, the study team developed a customized computer software package. This program allows the model to be efficiently applied to multiple study areas within the Sacramento and San Joaquin River basins. The program reads daily flow gage records and stage records and lets users select the ecosystem functions to be evaluated.

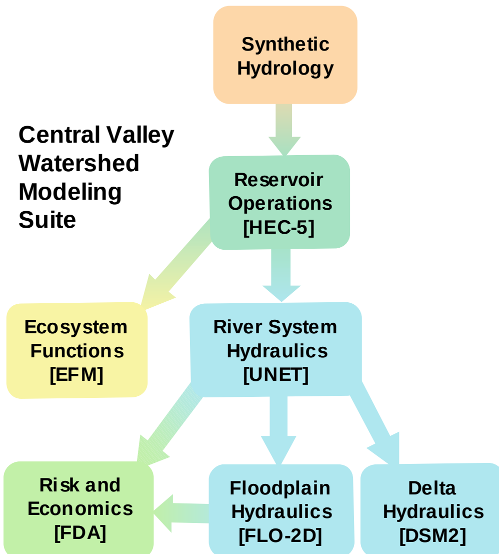


The EFM relates habitat conditions to hydrologic and hydraulic traits, such as water depth.

Step 3 - Hydraulic Analysis. Step 3 simulates the hydraulic response of the river system to the stream flows estimated in the hydrologic analysis step. The discharges are simulated in a Hydrologic Engineering Center - River Analysis System (HEC-RAS) hydraulic model (other models can also be used) to obtain simulated stages and flood inundation areas. HEC-GeoRAS can be used to create existing and potential with-project river cross-sections of study reaches for the HEC-RAS model, and export simulation results into a GIS environment for evaluation in Step 4.

Step 4 - Graphical Presentation. A GIS computer program is used to display the hydrologic/hydraulic simulation results together with other available geographic information, such as vegetative cover, soil types, land use, historic and existing topography, and ground water elevations. The graphical presentation helps ecologists spatially evaluate the biological relationships throughout the study reach.

Step 5 - Ecological Interpretation. The final step in the EFM involves interpretatior ˆ the modeling results and various environmental and landform features by ecologists. Based on predicted changes in terrestrial and aquatic habitat, conclusions or recommendations can be made on potential flood management and ecosystem restoration modifications.



What We Learned

The models work together to characterize the hydrology, hydraulics, ecosystem conditions, potential flood risk and economic damages in the Central Valley. The study team used them to gain a better understanding of the existing flood management system, perform various system-wide analyses, and evaluate "what if" scenarios suggested by team members, agencies, and stakeholders. Although these evaluations were performed at a watershed scale, they provide valuable information and insight on how the flood management system might be changed in the future.

The Sacramento and San Joaquin River basins each have distinct characteristics relating to climate, topography, land use, flood management, and the ecosystem. The timing and magnitude of flood flows varies significantly between the Sacramento and San Joaquin River basins. Flood peaks tend to last longer on the Sacramento River than in the San Joaquin River basin, which has a more arid climate. System-wide evaluations confirmed that a variety of approaches will be needed to effectively address the flood management and ecosystem needs of the two basins. One thing is common to both basins: the entire river system – including flood processes and ecosystem functions – is interdependent, and changes to one facet affect all others.

Assessment of the Existing Flood Management System

The existing flood management systems do not currently provide the levels of flood protection or sustainable ecosystem function desired by many people. The system's design did not provide a uniform level of protection to all lands. In general, urban areas were provided with the highest levels of protection followed by reclaimed lands, based on what the original system planners deemed appropriate and cost effective at that time. However, flood protection needs are different today, and ecosystem needs were not fully understood when the system was designed. Early designers did not fully understand the effects of constructing hundreds of miles of levees along such dynamic river systems. Over time, the natural erosive force of the rivers have affected levee integrity and made the system difficult to maintain.

- **Flood Conveyance Capacity.** Reaches of the flood management system may not be able to convey design flood flows due to factors such as reduced flow area, poor levee foundation conditions, deteriorating levees, and subsidence. Sediment accumulation, vegetation growth, and development encroaching on the floodway can cause reduced flow area. Although it was assumed when the system was designed that vegetation in the floodways would be maintained, conflicting maintenance practices and environmental protection laws along with local funding burdens have made maintenance increasingly difficult. In other areas, conveyance capacity is uncertain because levees are constructed on ancient river deposits that are prone to seepage. Repairing or improving these levees can be extremely costly, or infeasible.

- **Choke Points.** Constrictions or choke points in the flood management system can reduce conveyance capacity and/or increase stage. Some of these choke points are natural or were built into the system unintentionally (floodway constrictions), while others are the result of sediment accumulation, bridge construction, or infrastructure development. Bridge piers and abutments could be modified to improve flow capacity and reduce the potential for debris impoundment. Water supply intakes and other infrastructure could be modified in a similar manner, while maintaining their operation. Sediment removal by excavation or dredging can be a solution in some instances and can be considered on a case-by-case basis. Dredging could be effective in combination with other modifications where excessive sediment deposits cause a localized backwater effect, or where necessary to re-establish a primary channel. However, without other modifications to prevent reoccurrence, it is generally not a long-term solution. Federal participation in large-scale dredging projects does not appear feasible due to the extensive mitigation requirements and the inability of local entities to continually fund future dredging.

  While the hydraulic models developed by the Comprehensive Study lack the detail needed to identify highly localized choke points, the study team used them to identify constrictions that affect the system regionally. For example, Knights Landing is a major choke point in the Sacramento River system, hindering drainage from the Colusa Basin and constricting flows in the Sacramento River upstream from the Fremont Weir. The effect of this man-made floodway constriction can be seen as far upstream as Grimes in model simulations. Further, this portion of the river is perched above the surrounding floodplain, which limits potential actions to physically reduce the constriction by widening the Sacramento River floodway or the Knights Landing Ridge Cut. Other choke points in the Sacramento River Basin include Daguerre Dam on the Yuba River, various floodway constrictions on the lower Feather and Bear rivers, the earthen railroad and freeway embankments in the Yolo Bypass, the Highway 32 Bridge, and Woodson Bridge on the Sacramento River.

  In the San Joaquin River Basin, the conveyance capacity of the Chowchilla Bypass is constrained by several bridge crossings with earthen abutments that extend into the floodway. Other choke points in the San Joaquin River Basin include floodway encroachments on the Tuolumne River in Modesto, floodway and infrastructure constrictions on the San Joaquin River at the Washington Road and Grayson bridge crossings, and floodway constrictions on the San Joaquin River near Firebaugh. Many of the choke points on the San Joaquin River only cause problems during large flood events when the full capacity of the floodways and bypasses are utilized.

  > The general public does not have a common understanding of the actual risk of flooding and urban development continues in flood-prone areas.

- **Weir and Bypass Systems.** The Sacramento River basin has a complex weir and bypass system, effectively redirecting excess flood flows away from the Sacramento River. The Fremont Weir acts as a hinge point for the system, dramatically changing conditions in the Sacramento River, Feather River, and Sutter Bypass when it spills water into the Yolo

Bypass. The San Joaquin basin weir and bypass system functions differently, primarily intercepting flows from the major eastside tributaries before they reach the San Joaquin River. In contrast to the Sacramento River, some reaches of the San Joaquin River carry relatively little flow during flood events.

- **Ecosystem Conditions.** The river system supports only a fraction of the natural processes and habitat essential for a healthy, functioning ecosystem. Riverine ecosystems are dynamic and their health depends on an equally dynamic river system to drive ecological processes. These natural processes have been restrained by levees that constrict the river channels; reduction in seasonal flow variation due to reservoir regulation; water diversions; fragmentation and degradation of existing habitat; and the invasion of exotic species.

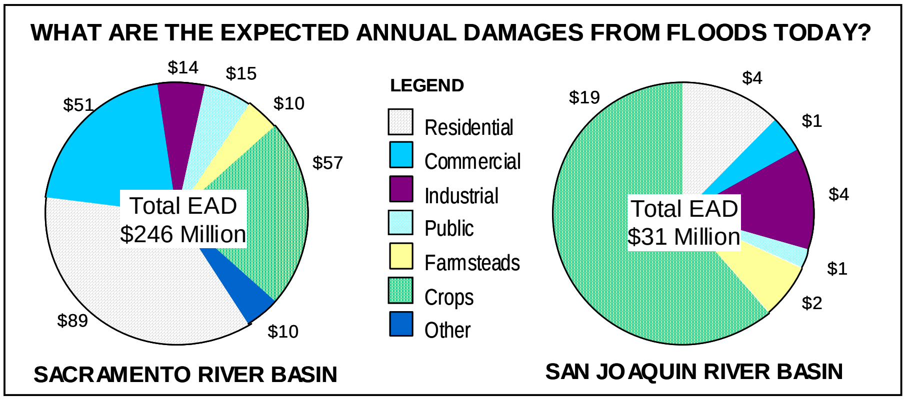
> Ecosystem restoration in the Central Valley can improve water quality, groundwater exchange, sediment transport, flood flow attenuation, and support a wide variety of habitat for special-status and other species.

- **Existing Reservoir Operation.** The study evaluated major flood control reservoirs to determine their ability to manage a range of flood events under their existing operational criteria. The table below provides an estimate of the level of controlled operations provided by each reservoir, or the flood frequency at which the reservoir can no longer maintain its objective flow criteria. The objective flow is shown in cubic feet per second (cfs). Model simulations evaluated the 50%, 10%, 4%, 2%, 1%, 0.5% and 0.2% flood events centered on each tributary; results can not pinpoint exact flood frequencies, but can provide a good indication of performance relative to the modeled floods.

Reservoir	Drainage	Objective Flow	Existing Flood Storage (TAF)	Flood that can be controlled without exceeding objective flow
Shasta	Sacramento River	79,000 cfs	1,300	1% flood
Black Butte	Stony Creek	15,000 cfs	136	almost the 2% flood
Oroville	Feather River	150,000 cfs	750	Between the 1% & 0.5% floods
New Bullards Bar	So. Fork Yuba River	50,000 cfs	170	1% flood
Pine Flat	Kings River	4,950 cfs	475	almost the 1% flood
Friant	San Joaquin River	8,000 cfs	170	4% flood
Hidden	Fresno River	5,000 cfs	65	almost the 1% flood
Buchanan	Chowchilla River	7,000 cfs	45	Between the 2% & 1% floods
New Exchequer	Merced River	6,000 cfs	350	almost the 2% flood
Don Pedro	Tuolumne River	9,000 cfs	240	4% flood
New Melones	Stanislaus River	8,000 cfs	450	1% flood

- **Land Subsidence.** Subsidence in the Sacramento and San Joaquin basins is caused primarily by groundwater overdraft. Portions of the southern San Joaquin River Basin have subsided more than 20 feet, prompting levees to be raised along the Eastside Bypass in 2000. In the Sacramento River basin, subsidence may also have affected the flow capacity of the Knights Landing Ridge Cut. If it continues, subsidence could threaten the basic function and efficiency of the flood management systems.

- **Flood Damages Today.** The HEC-FDA model was used to determine the EAD from floods. Total EAD was estimated in the Sacramento Basin at $246 million, and in the San Joaquin River Basin at $31 million. In the Sacramento River Basin, residential damages accounted for the highest proportion of flood damages ($89 million), followed by crops ($57 million), and commercial property ($51 million). In the San Joaquin River Basin, crop damages accounted for the highest proportion of damages ($19 million), followed by residential ($4 million), and industrial property ($4). These figures reflect differences in land development between the two basins. The Sacramento Valley has large urban areas at risk of flooding, whereas larger urban areas in the San Joaquin Valley tend to be located outside the 0.2% floodplain.



System-Wide Evaluations

The study used the models to perform various system-wide evaluations that provided a new understanding of how the system would react to large-scale changes to the flood management system. These "what if" scenarios varied widely, ranging from an approach that would restore the designed conveyance capacity system-wide, to an approach that would greatly increase the capacity of the floodways while allowing environmental restoration. The evaluations were both investigative and informative in nature, exploring the response of the flood management system to an array of flood damage reduction and ecosystem improvement scenarios, while developing analysis procedures using the Comprehensive Study modeling suite. The scenarios are not alternative plans. Highlighted below are some of the general findings from the system-wide evaluations:

- Because the original flood management systems were not designed uniformly, some levees were likely to fail before others. When levees fail and cause flooding in the adjacent floodplain, a substantial amount of floodwater leaves the rivers or bypasses, reducing flow rates and water surfaces downstream. Levee improvements that reduce the likelihood of failure reduce this temporary storage of water in the floodplain, increasing flow rates and flood risk downstream. To address the potential for redirected hydraulic impacts, solutions need to include measures to address the additional flow and volume of floodwater that could be transferred to downstream areas.

- All of the preliminary system-wide evaluations indicated that some amount of new flood storage is needed in the Sacramento River Basin, regardless of the type of flood management improvements implemented. Depending upon the types of modifications evaluated, new flood storage was needed to prevent transfer of hydraulic impacts to downstream reaches; reduce peak flows to levels that can be conveyed by the levee system; mitigate increases in flood flow entering the Delta; and accommodate ecosystem improvements within the flood management system.

- Most of the major tributaries to the San Joaquin River are controlled by reservoirs. However, these reservoirs provide widely varying levels of flood protection and, in general, provide less flood storage and management than reservoirs in the Sacramento River Basin. The only reservoir tributary to the San Joaquin River capable of controlling the 1% event is New Melones, while Friant Dam and New Don Pedro control about a 4% flood event. This is due, in part, to the type of development (primarily agricultural) that was present in the San Joaquin Valley when the flood management system was designed. Additional flood storage in the San Joaquin River Basin could provide significant flood benefits to the valley.

- The weirs and bypasses in the Sacramento River flood control system tend to dampen the effects of changes to the flood management system; as a result, some improvements provide less benefits than would be expected. Preliminary modeling indicated that new upstream storage provided the most benefit immediately downstream from the facility, but often had little effect farther downstream. This was due to differences in the timing of flood peaks on the tributaries and mainstem river and the redistribution of flows by the weirs and bypasses. For example, new storage in the Yuba River basin benefited Yuba City / Marysville, but had negligible benefits downstream from the Feather River.

- Under existing flood conditions, flow out of the Tuolumne River system overwhelms flow in the San Joaquin River downstream from the Tuolumne confluence. Thus, new flood control storage or other actions on the Tuolumne River would also have a significant influence on the lower San Joaquin River.

- The reach of the San Joaquin River south of Turner Island, which currently does not receive year-round flow, is an effective route for diverting flood flows and reducing stress on the Eastside Bypass. However, this reach can only convey an estimated 300-cfs and would require significant improvements to convey substantial flood flows.

- Vegetation was incorporated into some features of the flood management system (for example, trees planted to slow flows entering the lower Butte Basin), though much of the system was designed under the assumption that vegetation would be managed. The river system models developed by the Comprehensive Study have the ability to evaluate the regional and system-wide effects of

Habitat in the Flood Management System **–** While many people are concerned that vegetation is incompatible with a flood conveyance system, hydraulic modeling has shown how vegetation can be incorporated without adversely affecting flood stages or levee reliability. Enlarging the floodway with realigned levees, often to locations with more suitable foundation conditions, or locating vegetation in low velocity overbank areas, can reduce erosion potential and contribute to ecosystem restoration without reducing conveyance capacity. Enlarging the floodway can also help attenuate flood flows. Restoration with native habitat or farming -- similar to the existing bypass system -- are viable options for land within the expanded floodway. Habitat maintenance may be needed to preserve flood conveyance capacity.

different types and densities of vegetation on flood flows and stage. Vegetation in wide and shallow floodways, such as bypasses, has less impact than vegetation in narrow or constricted channels. Because flows move slower in the shallow bypasses, vegetation removal in the Sutter Bypass would provide less benefit than would be expected, and may actually increase damaging erosion on the levees. Model simulations also show that vegetation can be successfully incorporated into future flood damage reduction projects without affecting system capacity or reliability. In addition to providing habitat, vegetation can also provide benefits to the flood management system if it is properly incorporated into the design. For example, vegetated buffer strips or berms adjacent to levees can reduce levee scour and ease restraints on the management of vegetation growing on levee slopes. If floodways are widened, vegetation can help attenuate flows and reduce erosion.

- During floods, water leaves the foothills and moves through the different rivers and channels of the flood management system at different rates. The flood peak from one tributary might reach the mainstem hours or days before the peak from another tributary, and the mainstem flood peak might not coincide with either. Similarly, water moves more slowly through a wide bypass than it does through deep river channels, influencing the timing and duration of flood peaks downstream. Changing the flow capacity or velocity of a bypass changes the timing of downstream flood peaks, and might not produce desirable results. For this reason, it is important to evaluate potential changes to the flood management system basin-wide.

- A large portion of the lower and middle Sacramento River is perched, meaning that sediment deposition has raised the bed of the river above the surrounding floodplain lands. Widening the floodway in these areas may be difficult or infeasible because the land slopes away from the river and levees would need to be very tall. System-wide evaluations identified other methods to reduce stage in these regions, including additional upstream flood storage and modifications to the weir and bypass system that would divert more water into the bypasses. Preliminary model simulations found that widening the Fremont Weir could reduce flood stages on the Sacramento River as far upstream as the Tisdale Bypass, while also reducing flood stages in and around the City of Sacramento. The effects were less pronounced along the Sutter Bypass and Feather River.

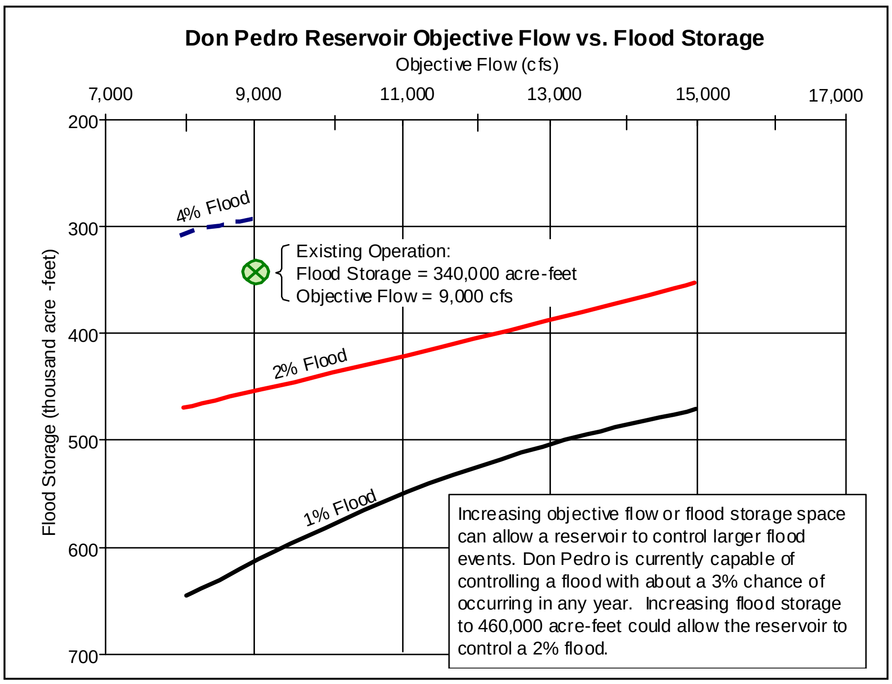
Floodwater Storage Evaluations

The study used the reservoir operations models to evaluate the benefits of re-operating existing reservoirs, additional flood storage in new or existing reservoirs, and temporary storage in floodplain areas that can tolerate (and be compensated for) infrequent flooding. Additional flood storage could provide flood damage reduction and ecosystem restoration benefits, or it could be used to offset redirected hydraulic impacts associated with conveyance improvements. New flood storage can be costly both financially and environmentally, but multipurpose projects – those that also provide water supply or hydropower benefits, for example - could be feasible when developed in collaboration with others. The CALFED Storage Program is considering opportunities for additional water supply reliability and other purposes through the reoperation or enlargement of reservoirs and the development of conjunctive use projects. Many of the potential CALFED storage projects also provide opportunities for additional flood storage.

The study evaluated a suite of potential storage projects near Friant Dam, based on previous CALFED investigations to determine the flood control benefits. The scenarios included various combinations of the following elements: raising Friant Dam, construction of Temperance Flat Dam on the San Joaquin River upstream from Friant, and construction of Fine Gold Dam on Fine Gold Creek upstream from Friant. All of the scenarios offered significant flow reductions as far downstream as El Nido for the 2% and 1% flood events, and one scenario offered significant flow reductions up to the 0.2% event (1-in-500 chance of occurring in any year). These preliminary results indicate that storage projects in this region could have flood control benefits for the San Joaquin River.

Another potential CALFED storage project involves raising Shasta Dam. However, preliminary Comprehensive Study model simulations indicate that increasing flood storage in Shasta would not provide significant flood benefits because Shasta already has a large flood storage allocation - enough to contain the 1% event. Under controlled flood operations, releases from Shasta account for a relatively small portion of flow in the Sacramento River downstream from Ord Ferry. Even if releases from Shasta were stopped completely, the numerous uncontrolled tributaries downstream from Shasta contribute a significant amount of flow to the Sacramento River during floods.

- **Reservoir Operation and Flood Storage Analysis.** The study performed a series of model simulations to evaluate how changes to flood operations could affect the performance of existing flood control reservoirs. The results of this analysis were plotted on grids, which show how increases in flood storage and/or objective flow could be used to increase the level of flood control provided by a reservoir. The "grid analysis" provides valuable insight into what benefits could, or could not, be achieved through modifications to the existing reservoir system.



- **Floodplain Storage.** Historically, low-lying basins adjacent to the Sacramento and San Joaquin rivers stored large volumes of floodwater that broke out of the river channels. Some of this water stayed in the basins and slowly evaporated, and some of the water was transitory, gradually draining back into the river system. Today, a similar principle could be applied to store excess floodwater off-stream, in floodplains adjacent to the rivers. The primary benefit of this type of temporary storage is that water is removed from the channel when and where it is needed most. Because foothill reservoirs can be very far away from the valley lands they protect, the timing of flood peaks from multiple tributaries can reduce the flood benefits farther downstream.

However, floodplain storage has limited applications in the Sacramento and San Joaquin basins. The storage area must be large enough to reduce the flood peak to safe levels, and flows often need to be diverted rapidly. Basin-wide evaluations found that flood peaks on the Sacramento River last for such a long time that few areas could store the large volume of water necessary, and very large capacity weirs were needed to divert the floodwater rapidly enough to be effective. Ideally, storage areas should also rely on topography to contain, and drain, the floodwater. Landowners must also be compensated; compensation could be in various forms, such as a one-time easement or reimbursement for damages each time the storage area is used. If the storage area is also used for agriculture, the crops must be compatible with infrequent, seasonal flooding or the area should be designed for use only during the most extreme floods, such as in the existing bypass system. Some high value permanent crops can sustain brief duration flooding.

Valuable floodplain habitat can sometimes be established in floodplain storage areas if the land is publicly owned or under conservation, but many habitat types require more frequent inundation than is desirable for flood management purposes. Model simulations of potential levee breaches along publicly owned land that is part of the San Luis National Wildlife Refuge found that the area becomes inundated before the flood peak arrives, providing negligible flood benefits. The area could provide flood attenuation benefits and conditions conducive to certain types of terrestrial ecosystems, but does not have the characteristics suited to floodplain storage.

- **Off-stream Storage.** Unlike typical in-stream reservoirs, off-stream storage is not located along the watercourse it benefits. Instead, water must be diverted to the off-stream storage area from a river that could even be located in another watershed. Typically, the diversions themselves do not provide the flood management benefits. Rather, additional flood space is made available in another reservoir by storing a portion of that reservoir's conservation pool (water supply) in the off-stream storage reservoir prior to the flood control season. Preliminary modeling investigated the potential flood management benefits of off-stream storage in the Sacramento River Basin. The analysis was not intended to evaluate specific locations, rather, to determine the effectiveness of any off-stream storage project in the basin.

  The modeling included simulated diversions to a hypothetical off-stream storage reservoir from the Sacramento River below Keswick and Stony Creek below Black Butte. Water diverted to the off-stream storage reservoir was exchanged for additional flood storage in six existing reservoirs: Shasta, Black Butte, Stony Gorge, East Park, Oroville, and Folsom. The representative off-stream storage reservoir in this analysis would function similar to Sites Reservoir, currently under investigation by CALFED. Results showed localized flood benefits on the tributaries where flood storage was added, but no significant flood flow reductions on the main stem of the Sacramento River. This is likely due to several factors: flows from unregulated tributaries; the difference in timing between tributary flood peaks (where flood space was added) and main stem flood peaks; and that Oroville and Shasta already control large floods (up to the 1% exceedence event).

- **Conjunctive Use.** Conjunctive use for the purpose of flood control would involve lowering reservoir storage levels below the flood control pool and storing the displaced conservation water in an aquifer for later, beneficial use. In this manner, flood storage is increased without sacrificing water supply or making costly dam modifications. Other potential benefits include reduction of groundwater overdraft and supplemental water supply. If the lowered pool is completely refilled later in the season, the stored groundwater may be reserved for dry years. The preliminary study found that conjunctive use could provide flood control benefits in both basins and warrants additional consideration. Although it is unlikely that a conjunctive use project could be successfully developed for flood management purposes alone, conjunctive use projects are being considered throughout the state to manage limited surface and groundwater resources.

Flood Conditions in the Delta

The study performed preliminary modeling in the Delta to gain a better understanding of the complex hydrodynamic conditions in the Delta during floods. Although the simulations were generalized, the results are informative and indicate how changes to the flood management system could affect the Delta.

Major factors that affect the flow of water through the Delta include tributary inflows, tidal cycles, water project operations, and the physical configuration of the levee and waterway network. The Sacramento River flood peak usually arrives at the Delta before the San Joaquin flood peak during smaller flood events, but for larger events, the peaks overlap due to the extended duration of Sacramento River flood flows. Studies indicate that the relative timing of peak flows arriving at the Delta may be more significant than the magnitude of the flows themselves, as a wide range of inflows result in similar stages.

During large flood events, sustained peak flows from the Sacramento River Basin strongly influence stages in the north and central portions of the Delta. Sacramento River inflows create a hydraulic barrier to flood flow from the San Joaquin River, and results in water “backing up” in the south Delta area. This effect is particularly strong during high tide conditions.

Channel improvements in the South Delta, including widening Paradise Cut, dredging Old River, and widening Middle River could evacuate San Joaquin River flood flows more rapidly during more frequent flood events, but the effectiveness of these improvements is reduced in larger flood events, when inflow from the Sacramento River dominates Delta hydrodynamic conditions.

The effect of this hydraulic barrier was evident during the 1997 flood, when high tide conditions and high flow from the Sacramento River dominated Delta hydrodynamic conditions. Flows

from the San Joaquin River were high, but less significant when compared with Sacramento River flood flows. Despite lower peak flows from the San Joaquin, most damages from flooding occurred in the south Delta because high stages from the Sacramento River prevented these flows from exiting the Delta. In addition, peak flows in the Cosumnes River were almost as high as those in the San Joaquin River, demonstrating the effect of the eastside tributaries.
Model simulations showed that the western Delta typically experiences increases in flood stage during low tide, but not during high tide periods. These results suggest that flood flows cannot overcome the influence of the ocean during high tide periods, but effectively ‘fill in’ the void left by the receding tide. This effects prolongs high stages. This effect also indicates that stages in the estuary downstream from Martinez are dominated by ocean tides and are less likely to be affected by changes in flood flows.

A sensitivity analysis was performed using DSM2 to identify how conditions in the Delta could be affected if flood flows in the Sacramento or San Joaquin rivers were increased. In general, these simulations found that increasing flood flows from the Sacramento River resulted in an increase in peak stage primarily in the central Delta region, with less significant stage increases to the west and the south. Increasing flows from the San Joaquin River resulted in an increase in peak stage primarily in the southern portion of the Delta, with less significant increases to the north, central and western Delta areas. This exercise provides an indication of the areas that would be most sensitive to projects that change the timing or magnitude of flows entering the Delta.

Because of their construction material, Delta levees are highly sensitive to changes in peak water elevation or increases in duration of peak stage. An increase in Delta inflow could raise peak stage and duration on hundreds of miles of Delta levees, thereby increasing flood risk. Preliminary evaluations suggest that a slight increase in peak discharge (less than 10 percent for some events) may be feasible if it is coordinated and implemented with improvements made under the CALFED Delta Levee System Integrity Program. However, more significant increases in flood flow to the Delta would likely increase peak water surface elevation and duration to levels that would not be economically feasible to mitigate and would pose unacceptable risk to critical water supply and transportation infrastructure. Additional detailed study is required to identify how levees would be affected by specific changes to Delta inflow.

Flood damage reduction studies are often based on a level of protection defined by storm frequency or return frequency. However, this approach is not appropriate to define the occurrence of tidal cycles, which also have a significant effect on flood stage in the Delta. Variations in tides originate from gravitational forces and planetary movements, and have little relationship, if any, to the recurrence frequency of flood events.

Ecosystem Functions

The study applied and tested the EFM in two pilot studies, one on the San Joaquin River near Vernalis and the other on the Sacramento River near Princeton. EFM results for the Vernalis pilot study, which evaluated existing conditions along a study reach, indicated that several locations along the pilot reach should support riparian vegetation. Field visits verified that areas predicted to have riparian vegetation by the EFM did in fact have willow and cottonwood seedlings that sprouted following the 1997 flood. The Princeton pilot study evaluated a hypothetical levee realignment that would re-connect floodplain land to the Sacramento River. Although the hypothetical project alleviated a choke point and reduced water surface elevations, EFM results predict that the extent of riparian vegetation would not increase significantly because the reconnected floodplain lands would not be inundated frequently enough. The two pilot studies demonstrate how the EFM can be used during planning and feasibility studies to predict biological response to proposed changes to the flood management system and help envision potential ecological improvements.

Floodplain and Watershed Management

- **Floodplain Management.** The Comprehensive Study included an evaluation of existing and potential floodplain management programs and measures that could be implemented in the Central Valley. The potential modifications considered included those that could be implemented locally, such as flood-proofing structures, and programs that could be implemented basin-wide, such as educational programs or flood risk mapping to encourage more appropriate land use in the floodplain. While many of the local measures will be considered during planning of future projects, the State of California or other agencies would be needed to implement basin-wide programs.

  The National Flood Insurance Program (NFIP), administered by FEMA, and other programs have significantly contributed to reducing flood damages through regulation of the floodplain. However, flood risk will rise as population in the regulatory floodplain grows and land adjacent to regulated areas is developed. Some of the causes of continued flood risk include:

  - Encroachment of urban development in the floodplains, sometimes aggravated by the limitations of and non-compliance with NFIP and State floodplain management guidelines.
  - Lack of updated floodplain and floodway maps that reflect changes in flood hydrology and channel geometry.
  - Approval of projects that do not address negative hydraulic impacts or effects outside the immediate project area.
  - Deferred channel and levee maintenance.
  - Lack of funding for flood protection projects and buyout programs for repeatedly flooded structures.
  - Lack of understanding or awareness of the actual risk of flooding, both within and outside of the regulated floodplain.

- **Residual Risk.** After a flood management project is built, some risk of flooding will always remain from unexpected problems, larger floods, or uncertainty associated with the technical data used to design the project. Information about the threat of flooding needs to be communicated throughout the study area in a manner

> As future projects are developed, there is a need for technical assistance to communicate flood risk to emergency services and management; provide floodplain management education and outreach programs; and develop multi-parameter flood threat maps that can be used with traditional floodplain maps to make more informed land use decisions.

that will broaden the current level of understanding. Typically, floodplain mapping is used by local entities to guide land use decisions in areas that are subject to flooding and require flood insurance. In their current form, these maps do not illustrate residual risk or risk to adjacent lands. In addition to the frequency of potential damages, citizens and decision-makers also need to understand the potential severity of damage (five inches versus five feet of floodwater) and threat of loss of life that would result from flooding. For example, residual risk is higher in densely developed areas that would be subject to rapid, deep flooding – such as areas protected by high levees or areas with limited evacuation routes.

The Corps Hydrologic Engineering Center is developing ways to visually communicate residual risk through multi-parameter flood threat mapping. While traditional floodplain mapping is typically limited to flood frequency and extent, risk-based mapping identifies other hazard factors such as the depth of flooding, flood warning time, and the velocity of floodwaters. HEC's effort is near completion and a draft document is anticipated the first week of December 2002.

> Residual risk is the portion of the flood risk that still exists following completion of a flood damage reduction project.

- **Emergency Preparedness.** The existing flood management system includes flood warning and response features that provide information to emergency response personnel throughout the river basins. Because of the rapid rainfall-runoff characteristics of the Sacramento and San Joaquin River basins, current warning time is measured in mere hours. Additional data collection and dissemination features, along with improvements in current weather forecasting capabilities, could lengthen warning time and increase opportunities to implement forecast-based reservoir operations. The Reclamation Board, DWR, and the Corps, working with the State and Federal Joint Operations Center - the emergency response center for flooding and hazardous weather - are conducting a study to determine if there is a feasible project to improve existing flood warning time and emergency preparedness. This study is the Enhanced Flood Response and Emergency Preparedness project. (see Potential System-Wide Measures section in this report for more information).

> Because of the rapid flooding nature of the Sacramento and San Joaquin River basins, warning time is measured in hours in some locations.

- **Urbanization.** The Corps' Hydrologic Engineering Center performed a preliminary study to evaluate the effect of urbanization on flood flows. Urban land development results in an increase in impervious area, reducing percolation and increasing rainfall runoff. Study results confirmed that increased land development is accompanied by an increase in both peak flow and runoff volume, with the greatest increases observed in runoff volume. Urbanization had the greatest effect on more frequent storm events (more frequent than the 4% event), and the location of urbanization within the watershed influenced its effect on runoff flows and volumes.

The Comprehensive Study Provided System-Wide Understanding

Hydrology – Nineteen historic flood events (including the January 1997 storm) were used to estimate the runoff that would result if no reservoirs existed in the watershed.

Reservoir Operations – Over seventy reservoirs were modeled to determine regulated flood flows, making this the largest application ever of the Corps' reservoir modeling tool.

Levee Reliability – Levees can fail when the river overtops them, when they erode, or when water seeps through or under them. A preliminary system-wide assessment estimated how levees could perform during various flood events.

Hydraulics – Generally, floodwaters flow within the defined system of channels, weirs, and bypasses. Hydraulic models assessed the flow and water surface in these systems and how the flows moved onto the floodplain when banks were overtopped or levees failed.

Composite Floodplains – When flood flows leave the channels because of overtopping or levee breaks, the floodplain could be inundated. Because no one storm would produce the same frequency of flood flows throughout the Sacramento and San Joaquin River basins, composite floodplains were developed. Detailed topography and hydraulic models estimated the rate and depth of water flow over the floodplain.

Economic Damages – Land uses in the inundation areas were analyzed to estimate potential economic impacts of flooding. Economic impacts result from agricultural damage and production losses, damage to structures and their contents, damage to infrastructure, and the movement of goods and services.

Flood Warning and Response – The existing flood management system includes tools to examine data to determine if a flood threat exists and forecasting tools to determine if a threatening situation may develop. These tools were reviewed to identify opportunities to increase warning time through improved data collection and dissemination and additional emergency response planning.

Floodplain Management Programs and Measures – Existing Federal, State and local floodplain management programs were reviewed to identify potential improvements and new floodplain management measures that would promote flood safety and ecosystem restoration in the floodplain.

Biological Response to Flows – The EFM was developed to assess how changes in the river flow would affect the river-floodplain environment. Successful pilot testing at two locations indicates this tool has value in estimating ecosystem response to future projects.

Basin-wide Storage Opportunities – Major flood storage reservoirs in the Central Valley were reviewed to identify the potential effects of additional flood space or changes to controlled flood releases. Some reservoirs coincide with sites considered in the CALFED Integrated Storage Investigation (ISI) Surface Water Storage Program.

Conjunctive Use – Assessment of system-wide opportunities to lower reservoir storage levels below the flood control pool and then transfer this displaced water to groundwater storage found this method to be potentially feasible.

Watershed Land Use Changes – Evaluation of a test site concluded that increases in urban development in the watersheds would cause a measurable increase in the runoff for more frequent (storms up to the 1-in-25 year event), but the increases were less pronounced for larger storms.

Subsidence – Subsidence, or the lowering of ground surface, can significantly affect flood system design and performance. Topographic data show that subsidence has had a more pronounced effect on flood conveyance facilities in the San Joaquin River Basin than in the Sacramento River Basin.

How Can We Influence Future Conditions?

Vision

The Corps and The Reclamation Board share a vision for the Sacramento and San Joaquin River floodplains as areas where the inhabitants are relatively safe from flooding and enjoy the benefits of a healthy, sustainable ecosystem and a strong agricultural-based economy.

Planning Objectives

- Reduce the risk to human life, health, and safety due to flooding.
- Promote natural dynamic hydrologic and geomorphic processes.
- Reduce damages due to flooding.
- Increase and improve the quantity, diversity, and connectivity of riparian, wetland, floodplain, and shaded riverine aquatic habitats, including conservation of agriculture and its ecological value.
- Minimize the flood management system operation and maintenance requirements.
- Promote the recovery and stability of native species populations and overall biotic community diversity.

Broad Planning Objectives

The planning objectives, developed early in the study process, are the desired future effects to be achieved by solving the flooding and ecosystem problems.

Stakeholder Interests and Concerns

Potential projects depend on stakeholder interest in pursuing regional or local projects. If there is no stakeholder interest, there will be no projects. If a local area is interested in pursuing a project, having a regional coalition representing the varied views of stakeholders will help the planning and appropriation processes.

Stakeholder interests and concerns vary widely from place to place within the Central Valley due to the extensive geographic area and diverse land uses. These interests and concerns may vary widely within the same community. Some people have stated that they want no projects and that they are content in dealing with future emergencies when they occur. Others want the system simply repaired in place. Some people envision an expanded system with new facilities or more room for the river to meander.

This collective input was instrumental in forming the Comprehensive Plan into a process to guide local development of future projects. Stakeholders are in general agreement on the merit of a comprehensive system-wide solution, but, because interest and concerns vary widely, agreement is lacking on the specific physical components of such a project. This is due, in part, to uncertainty on how to develop potential future changes to the flood management system to achieve true integration of flood damage reduction and ecosystem restoration objectives without compromising one for the other. This coordination also highlighted great concern among stakeholders that potential future projects be developed with consideration for system-wide aspects of the rivers and not compromise public safety. While it is technically possible to develop a system-wide, physical project for the flood management system, attempts to formulate such alternative system-wide projects were not successful.

Stakeholders commented on the content of the Draft Interim Report and preparation of the Comprehensive Plan, the shortcomings of the existing flood management system, and on other issues outside of the Comprehensive Study purview.

The following is a broad summary of the types of comments received during the Comprehensive Study:

- There was concern that projects would be forced on property owners against their will, that they would lose their property and water rights, or that they would not be compensated for the loss of their property. Even with appropriate compensation, changing land uses could affect local economies, the tax base, and third parties.

- Specific ideas on desired projects include new surface storage such as Sites Reservoir and Auburn Dam, small reservoirs in Colusa County, modifications and reoperation of existing reservoirs, more bank protection to stop erosion, sediment management, dredging, passive levee breaks, more ecosystem restoration, levee realignments, in-place levee repair, and elimination of choke points. Some comments were against levee realignments or ecosystem restoration. A few comments were against all projects. Some expressed concern over continual study and just wanted to implement projects.

- Some interest groups believe that flooding problems can be reduced by better operation of the existing system and that new surface storage is not needed. These groups generally believe that native habitat can be compatible with the flood management and that the river systems would be improved if they had more contact with their historical floodplains to enhance ecosystem functions and processes.

- Some wanted to see specific benefits added to the scope of the Comprehensive Study such as new water supply, water quality, control of invasive species, navigation, or reducing flood backup into agricultural systems or control of specific local problems.

- There was general interest in how future projects would be implemented. These include interest in protecting public safety, questions on how decisions would be made, the need for public education, concern over unequal permitting, need to keep levee districts autonomous, opposition to ecosystem authority for The Reclamation Board, belief in the incompatibility of flood management and ecosystem restoration, the need to protect infrastructure, and concern over so many constraints on development.

- Regional and local stakeholders expressed great concern about the lack of a consistent approach to system-wide maintenance activities and funding.

- Many stakeholders had a general interest in seeing more technical information and having access to the models.

- There was a general concern over the current requirements for project justification, which defines the level of State and Federal participation in a project, fearing that rural areas may not be able to justify or afford needed system fixes.

- There were concerns over ongoing programs by others. These include concerns that the policy issues developed to date lack broad regional support, concern over the work of the California Floodplain Management Task Force, and concern that FEMA negotiations should be kept with the local entities.

- The Reclamation Board and the Corps can only make recommendations for future investments within the existing laws and policies. However, some stakeholders want existing laws changed. For example, some want to change the Endangered Species Act to exempt the flood management system, change FEMA regulations and change PL 84-99 to allow fixing problems before system failures occur. Changes to existing law can only be accomplished through normal Federal and State legislative processes.

Although stakeholders provided many more comments, those shown above are a representative sampling of the types of comments received. Following public forums to review the Draft Interim Report, the Comprehensive Study team prepared written responses to stakeholder comments on their interests and concerns. Copies of the Response to Comments Document are available upon request.

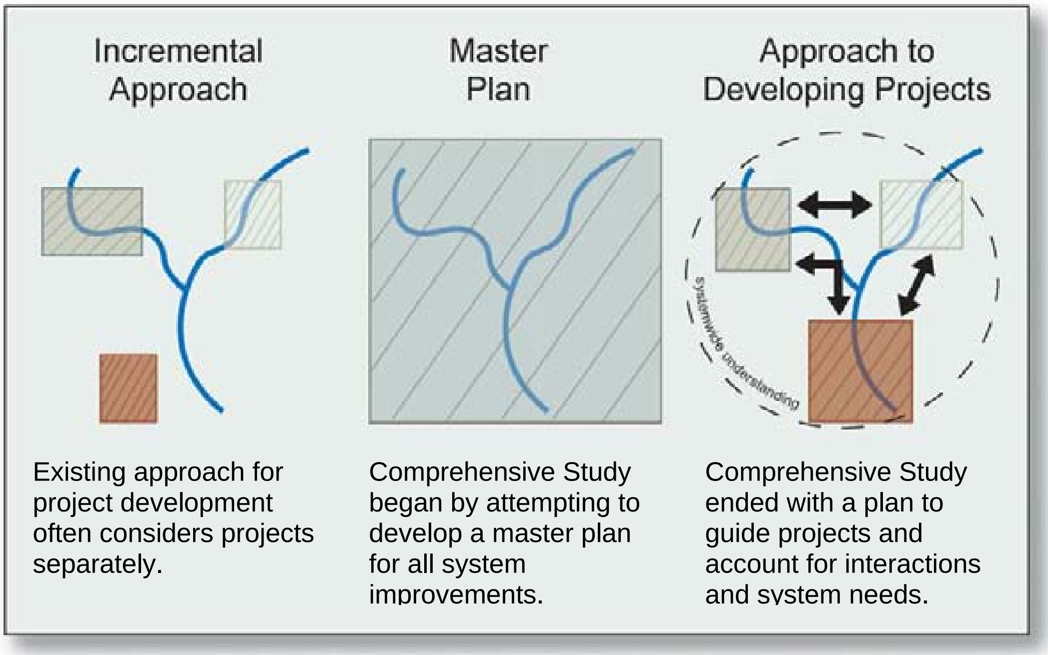
The collective stakeholder interests and concerns have directly influenced the composition of the Comprehensive Plan and its future implementation. For example:

- The implementation section of the report now includes a recognition of landowner rights.
- The report makes no recommendations for specific projects. All potential measures are available for consideration during future detailed planning of regional and local projects.
- Multiple benefits beyond those for flood management and ecosystem restoration can be considered to improve benefits for project justification.
- The report now includes more implementation detail for future projects.
- The report acknowledges the need to improve system maintenance.
- Supporting technical information and models are available on request.
- The process for identifying and resolving implementation issues will continue and include all interested parties.

Regional and local projects will provide new opportunities for stakeholders to express specific interests and concerns as well as to craft projects that meet the local needs.

Future projects under the Comprehensive Plan will examine the potential effects of flood management system changes on rural communities and the public health and financial impacts of ecosystem restoration and flood damage reduction on minorities and disadvantaged people living in rural as well as urban areas.

Approach to Developing Future Projects



The current, piecemeal **incremental approach** to developing flood damage reduction and ecosystem restoration projects has the potential to allow adverse effects to the existing flood management system and the ecosystem.

The Comprehensive Study team originally worked to develop example **master plans** for the entire system. Public views on needs and expectations are so diverse that planning and construction of a single system-wide physical project is impractical, at this time, and in fact would likely take decades to attain consensus.

A new **approach to developing projects** is needed to assure that local and regional flood damage reduction and ecosystem restoration needs are addressed while also maintaining a system-wide perspective. The technical findings suggest that the hydraulic characteristics of the Sacramento and San Joaquin River basins are conducive to regional project development. A process can be developed to guide future project development and ensure consideration of the system.

Measures to be Considered in Future Project Development

Perhaps the most significant finding from the system-wide evaluations is that no single type of modification will be sufficient to address flood damage reduction and ecosystem restoration objectives in the Sacramento and San Joaquin River basins. Rather, a broad range of flood flow and floodplain management measures that would reduce flood damages and promote ecosystem restoration should be considered during future project planning. A series of Central Valley outreach meetings/workshops with Federal, State, and local agencies and other interested groups and individuals identified numerous measures during the Comprehensive Study. Technical studies show, and stakeholders concur, that three broad categories of measures involving changes in the flood management system are needed to reduce flood damages and restore the ecosystem:

- **Flow Conveyance Measures.** Levees and floodplains can be modified to increase their capacity and reliability to carry flood flows while providing opportunities for ecosystem restoration. These measures provide opportunities to restore geomorphic processes and riverine habitat within the river corridor.

- **Storage Measures.** Regulating floods by storing water during periods of high flow and releasing water more slowly at a later time reduces peak flows and the extent of downstream flooding. Modified flood flow patterns can improve ecosystem processes. Storage measures include both foothill reservoir and floodplain areas.

- **Floodplain Management Measures.** Floodplain management includes measures to reduce or avoid property damage and personal injury that result from flooding, and measures that provide opportunities for conservation, natural floodplain processes, and restoration of the riparian corridor. Modifications to floodplain management can include new hazard-based flood mapping, flood hazard mitigation, floodplain protection, hydraulic and ecosystem mitigation banks, and avoidance of future development.

Agriculture in the Floodplain

Sustaining agriculture in the Central Valley is essential to ultimately achieving the Comprehensive Study objectives. The future of sustainable agriculture, effective flood management, and healthy, restored ecosystems is intertwined and face the common threat of urbanization that converts land to non-agricultural uses. The importance of the family farm in this future lies in the habitat values of the diverse cropping patterns and traditional farm practices they offer. While restored ecosystems can flourish when surrounded by agriculture, they face ultimate failure in the midst of expansive urban development.

Agriculture, restored habitat, parklands, and other open space landscapes are all compatible uses of the floodplain that avoid escalating threats to property and public safety. All floodplain areas, even urban areas with high levels of flood protection, can eventually flood when a sufficiently large flood overwhelms the flood management system. When flooding occurs, the disruption to open space lands is generally less than in urban areas due to the lower property damages and fewer affected people. The Corps and The Reclamation Board fully expect that future projects will reduce flood damages throughout the basins, in rural areas as well as in urban areas. Part of this improved flood protection could be accomplished by occasional, planned flooding, with appropriate easements and compensation, in limited designated areas.

Example Partnership

The Cosumnes River Preserve, a nationally recognized effort to protect and restore endangered ecosystems and its associated high habitat value rangelands and farmlands, demonstrates the value of agriculture/ecosystem partnerships. Of the approximately 40,000 acres involved with the Preserve, either through fee title ownership or conservation easement, 92% are actively farmed in a manner that is environmentally sustainable, community supported, and economically viable.

Various existing programs provide opportunities to both improve ecosystem structure and function and partner with the agricultural community to make farm activities more competitive and improve cash flow. Agricultural lands can provide foraging and breeding habitat and provide a buffer between urban development and native habitat. This buffer not only minimizes disturbance of the habitat, but can also provide upland areas where wildlife is able to escape from flooding. Just as agricultural practices can be modified to be more wildlife-friendly, so too can wildlife management practices be modified to be more agriculture-friendly.

The Comprehensive Plan

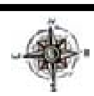
System-wide analyses have shown that there are no easy solutions to protect the Central Valley from flooding while simultaneously improving ecosystem conditions. Preparing a plan for a system of existing dams, levees, and developed floodplains is different from a situation where few facilities are in place. Rather than proposing a list of specific projects for immediate implementation, the Comprehensive Plan defines a process for developing future projects.

Recognizing that changes will be made incrementally, perhaps over several decades, the Comprehensive Plan provides guidance for improvements to flood management and ecosystem restoration in the Sacramento and San Joaquin River basins.

While not a physical plan, the Comprehensive Plan seeks to address identified problems by first institutionalizing consideration for system-wide effects to the flood management system and then setting the stage for future project development. The Comprehensive Plan establishes: (1) a set of principles to guide future projects; (2) an approach to develop projects with consideration for system-wide effects; and (3) an organization to consistently apply the Guiding Principles in maintaining the flood management system and developing future projects.

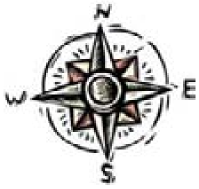
Why Do We Need a Plan that is Flexible for Future Project Planning and Construction?

- Planning and construction likely spans several decades.
- Numerous projects are required on different time frames.
- Authorization and funding for projects are likely to occur incrementally over time.
- Future funding is not assured for specific implementation features.
- Projects may require partnerships with many local sponsors whose needs and ability to participate vary significantly.
- Ecosystem and individual wildlife, fish, and plant populations will respond differently to changes in flood management and restoration programs over time.
- Adaptability is needed to respond to changing future conditions.
- A plan must provide guidance for future improvements as they become justified.
- Future population growth will change many aspects of California’s physical and sociopolitical environment.

	**Guiding Principles**
	**Approach for Project Development**
	**Administrative Structure**

It is critical that all changes to the flood management system be considered on a system-wide basis. **The intent of the Comprehensive Plan is to guide all Federal, State, and local agencies, groups, organizations, and individuals in planning and constructing projects within the flood management system.**

Guiding Principles



A set of basic principles is needed to ensure that changes to the flood management system integrate flood damage reduction and ecosystem restoration, while considering system-wide implications of those changes. The Guiding Principles were designed in response to this need to (1) promote coordination and partnerships for the public good, (2) reduce or eliminate conflicts, and (3) serve as a guide for modifications to the flood management system. They were established and refined through agency coordination and public outreach to address the wide range of stakeholder concerns to integrate flood damage reduction and ecosystem restoration, and to ensure a system-wide approach in evaluating proposed changes. These principles will guide the planning of changes to the flood management system and will be applied to future studies and projects regardless of their areal extent or level of detail. The Guiding Principles will apply to anyone planning projects that modify effect of the flood management system. Projects should demonstrate that they are consistent with the Guiding Principles. In addition to compliance with the Guiding Principles, each project will be subject to site-specific environmental documentation and mitigation requirements.

Each of the Guiding Principles supports a **system-wide approach** for project planning**.** The Sacramento and San Joaquin rivers function as hydrologic systems, and ecosystem needs are tied to hydrologic processes. Accordingly, one must approach these rivers as complete systems when considering flood damage reduction and ecosystem restoration objectives. The fact that these rivers have not been consistently treated as comprehensive systems in the past has led to some of the problems that are experienced today. Focusing on flood management within limited reaches without full consideration of hydraulic effects in reaches both upstream and downstream has resulted in modifications to the system that have shifted local problems to other reaches. Likewise, the cumulative impacts of modifications to the system have contributed to a general decline in the health of the ecosystem. The cumulative impacts of habitat restoration projects can also reduce flood conveyance. It is important to ensure that the integrity and continuity of the system is maintained and enhanced to allow the river system to function in a manner where flood management and the ecosystem are compatible.

The following Guiding Principles are integral to achieving a system-wide approach to flood damage reduction and ecosystem restoration along the Sacramento and San Joaquin rivers.

1) Recognize that public safety is the primary purpose of the flood management system. Proposed changes to the flood management systems must not compromise public safety. The flood management systems for the Sacramento and San Joaquin River basins were authorized, designed, and are operated to protect public safety. Public safety considerations include the transportation and communications infrastructure necessary to accommodate an effective emergency response program. Since flooding often results in widespread economic and social hardships, it is recognized that protection of public safety is the primary purpose of the flood management systems. Public safety means increased security for people, infrastructure, and agricultural production.

2) Promote effective floodplain management. The floodplains of the Sacramento and San Joaquin rivers include overflow areas that store and convey large volumes of floodwater during flood events. This storage contributes to the flood protection of downstream property. All projects proposing modifications to the flood management system should consider the benefits of the roles of the floodplain in flood management and maintaining ecosystem processes. It is important to recognize that floodplains can be managed to further reduce damages and to avoid future damages without changing flood frequencies or modifying existing uses. It is essential to encourage and promote effective floodplain planning and management practices that improve public safety, reduce the susceptibility to damaging floods, preserve agriculture and habitat, and restore degraded ecosystems in the floodplain. Effective floodplain management involves actions that remove or modify damageable property; adapt land uses to be more compatible with flooding; influence future project decisions that benefit social, agricultural, and environmental values; and discourage development in areas with high flood risk. A clear communication of residual risk in those areas protected by structural features of the flood management system will encourage improved floodplain management practices.

3) Recognize the value of agriculture. Future projects will take into account individual and cumulative impacts of project development on agriculture and other open space lands, the flood damage reduction and ecosystem benefits of these lands, the economic and environmental effects on crop production, and the effects on associated service industries, infrastructure, and local communities. Agricultural lands in the Central Valley contribute significantly to the economy and quality of life in the region, the state, and the nation, and provide essential habitat components for many important species. Agricultural and open space lands offer substantial benefits in protecting natural values and in incurring lower monetary flood damages than more intensive land uses.

4) Avoid hydraulic and hydrologic impacts. The hydrology and hydraulics of the Sacramento and San Joaquin rivers and associated floodplains and ecosystems will be considered as complete systems at local and watershed levels. Studies clearly demonstrate that the hydrologic and hydraulic characteristics of the waterways and associated floodplains and ecosystems of each river basin represent a complete and interconnected system, and that changes to one part of the system will change other parts of the system. Future projects will be evaluated individually and cumulatively to ensure that there are no significant hydraulic effects to other lands and communities along the system and to ensure compatibility with local and regional flood damage reduction and ecosystem restoration goals. In working towards the restoration of a dynamic river system, some effects may be considered either beneficial or adverse, depending upon what is being affected. Each proposed project will undergo assessment for its potential effect on all aspects of the flow regime (flood magnitude, timing, duration, frequency, and rate of change) that affect natural functions such as sediment supply, transport and deposition processes, and channel cross-sectional and planform changes, as well as man-made and natural resources, upstream and downstream of project sites. Hydrologic evaluations will take into account the best available information on the effects and uncertainties of potential climate changes.

5) Plan system conveyance capacity that is compatible with all intended uses. Future projects that modify system conveyance capacity will utilize a watershed approach to establish system conveyance capacities that are compatible with release rates for reservoirs and functional geomorphic and biological processes. Modifications to conveyance capacities should account for effects of restored habitat.

6) Provide for sediment continuity. Management of sediment throughout the river systems is critical for maintaining the ecosystem and flood damage reduction functions of the river corridor. Providing for more natural movement of sediment through a river system will balance areas of erosion and deposition and support the dynamic habitat changes that characterize a healthy, self-sustaining riverine ecosystem. Future projects should be consistent with an integrated flood management design, including sediment inputs, that provides a balanced sediment budget within the channel to benefit geomorphic processes and riparian habitats, maintains the integrity of the design capacity, and reduces maintenance costs.

7) Use an ecosystem approach to restore and sustain the health, productivity, and diversity of the floodplain corridors. The ecosystem approach restores and sustains the health, productivity, and biological diversity of ecosystems by factoring in a full range of ecological components in project planning. The ecosystem approach recognizes and seeks to address the problems of habitat fragmentation and the piecemeal restoration and mitigation previously applied in addressing natural resources. Ecosystem restoration uses a systems view in assessing and addressing restoration needs and opportunities and in formulating and evaluating alternatives. Biotic resources are dependent on, and functionally related to, other ecosystem components. Recognition of the interconnectedness and dynamics of natural systems interwoven with human activities in the landscape is integral to this process. The philosophy behind ecosystem restoration promotes consideration of the effects of decisions over the long term and incorporates the ecosystem approach. Future projects will consider the needs of native aquatic, wetland, and terrestrial communities to improve the potential for their long-term survival as self-sustaining, functioning systems.

8) Optimize use of existing facilities. Significant contributions to both flood damage reduction and ecosystem restoration may be attainable through integrated or facility-specific reservoir re-operation, integrated use of public land for multiple purposes, and protection and management of existing high-value habitats within the flood management system. Therefore, the operation and management of existing facilities could be optimized to reasonably maximize system benefits and minimize the need for new facilities. Presently, there is a substantial array of facilities that directly or indirectly contribute to flood management and/or ecosystem health along the Sacramento and San Joaquin rivers. The objectives of the general design, construction, and operation of these facilities is to meet the needs of the immediate impact area or limited resource targets. At the time these facilities were constructed, it was not possible to measure or take into account effects that may have occurred in other areas of the river system. Because of their design and information available at the time of their construction, many existing facilities do not achieve their full potential for providing ecosystem benefits. The system-wide models can be used to evaluate system-wide effects.

9) Integrate with the CALFED Bay-Delta Program and other programs. Future projects should consider the status and objectives of ongoing flood management and ecosystem restoration programs, including, but not limited to CALFED, to ensure awareness of other planning efforts and prevent unintentional conflicts in designs or duplication of efforts. Projects need to recognize and support the CALFED single blueprint for ecosystem restoration and species recovery in the Bay-Delta and its watershed. To the extent possible, projects should integrate and adopt those CALFED ERP goals, objectives, targets and programmatic actions associated with the flood management system of the Sacramento and San Joaquin rivers, and incorporate conservation measures from the CALFED Multi-Species Conservation Strategy (MSCS). In that context, future projects will give priority to those actions that provide benefits for both flood damage reduction and ecosystem restoration. The CALFED science program and CALFED's considerable institutional and administrative framework was established to expand and communicate relevant, unbiased scientific knowledge, monitor performance, implement an adaptive management process, and measure progress. Future projects should build upon the CALFED ERP, rather than develop independent, parallel restoration programs, and implement applicable portions of the CALFED ERP to the extent of potential non-Federal sponsor interest. Additionally, future projects should take into account the floodplain areas and conveyance capacities needed by major regional planning efforts such as the San Joaquin River Management Plan (SJRMP) and the Sacramento River Conservation Area Forum (SRCAF).

10) Promote multi-purpose projects to improve flood management and ecosystem restoration. Proposals for modifying the flood management system for the primary purpose of either flood damage reduction or ecosystem restoration should consider opportunities for benefiting more than a single purpose. Multiple-purpose projects are more effective, considering costs and resource conservation. Projects that include both flood damage reduction and ecosystem restoration (as well as other potential purposes) will foster partnering, reduce conflicts, and serve the overall public interest. In accordance with State law, projects with multiple-purposes are eligible for increased State cost-sharing.

11) Protect infrastructure. Future modifications to the flood management system should consider direct and indirect impacts to infrastructure, including, but not limited to transportation (highways, railroads, navigation), communications, utility, and water transport systems. Transportation corridors and facilities are necessary for economic viability, emergency/evacuation response, and public safety. Potential impacts to infrastructure could limit future options and could result in unintended consequences.

Approach for Developing Projects

Projects to implement the Comprehensive Plan will be developed on three scales: system-wide, regional, and local. Regardless of their scale, each project must be evaluated to determine the system-wide effects. The extent of shared public view on needs and expectations should define the extent or scope of projects:

- **System-wide Projects.** System-wide projects could be pursued if there is broad public support. Such projects have the potential to yield more total benefit for less individual cost. Public views on needs and expectations are so diverse that planning and construction of a single system-wide physical project is impractical at this time and in fact would likely take decades to attain. For that reason, projects are more likely to occur at the regional or local level where stakeholders can work through the common issues as projects are developed. Therefore, system-wide projects are likely to be primarily non-structural in nature.

- **Regional Projects.** Study findings show that because of complex inter workings of the flood management system, major changes should at least be accomplished at a regional level. Evaluations for the Comprehensive Plan identified seven regions that share common characteristics: the upper, middle and lower Sacramento River regions; the Feather River region; the American River region; and the upper (south) and lower (north) San Joaquin River regions. Because hydrology, hydraulics, flood management system features, and land uses tend to be unique to each of these regions, there are issues unique to each; one can anticipate that regional projects will be developed. Focusing on these regions allows for issues common to stakeholders to be worked through as projects are developed.

- **Local Projects.** Local, or site-specific, projects will always be pursued to address specific problems. Many entities will continue to undertake these local projects.

The comprehensive approach to developing projects maintains that these three scales of projects can be pursued by any entity, as long as consideration of the river systems is highlighted and the Guiding Principles are applied.

Administrative Structure

The Reclamation Board intends to provide direction, oversight, and day-to-day management necessary for (1) consistent and reasonable application of the Guiding Principles, (2) minimizing costs and redundancies, (3) facilitation of partnerships, and (4) incremental project planning and construction. The Reclamation Board currently has all these responsibilities and authorities for the Comprehensive Plan area.

The Comprehensive Plan is designed to maintain a system-wide perspective while projects are planned and constructed. A long-term perspective must be maintained while accommodating the projects proposed by all entities.

Comprehensive Plan Implementation

Projects will be planned and constructed as local support is established, which could extend over several decades. The sequencing of project planning and construction will depend on the needs, resources, and availability of funding and participation of local interests, local government, non-profit groups, non-governmental groups, and State and Federal agencies.

Following are brief descriptions of important implementation aspects for projects under the Comprehensive Plan.

Administrative Structure

The Reclamation Board will continue to provide the administrative structure and fulfill the functions listed as part of the Comprehensive Plan.

The Reclamation Board Mission Statement

To control flooding along the Sacramento and San Joaquin rivers and their tributaries in cooperation with the U.S. Army Corps of Engineers.

To cooperate with various agencies of the Federal, State and local governments in establishing, planning, constructing, operating, and maintaining flood management works.

To maintain the integrity of the existing flood management system and designated floodways through the Board's regulatory authority by issuing permits for encroachments.

The Reclamation Board currently has all the responsibilities and authorities necessary to oversee future modifications to the flood management system. The Board has existing regulatory authority within the Central Valley regarding encroachments into flood management projects, floodplains, floodways, and drainage areas of the Sacramento River and the San Joaquin River and their tributaries and distributaries. The Reclamation Board's regulations are also intended to comply with its obligations to the U.S. Army Corps of Engineers pursuant to numerous assurance agreements, Corps Operation and Maintenance Manuals, and 33 C.F.R. Section 208.10.

The Reclamation Board's Authority

(Regulations of The Reclamation Board, Title 23, Waters, Division 1, Chapter 1, Article 1, Section 2)

(a) The purpose of these regulations is to carry out the board's duties pursuant to Water Code sections 8534, 8608 and 8710 - 8723. Under these statutes, the Board is required to enforce, within its jurisdiction, on behalf of the State of California, appropriate standards for the construction, maintenance, and protection of adopted flood control plans that will best protect the public from floods. (b) The area of the board's jurisdiction includes the entire Central Valley, including all tributaries and distributaries of the Sacramento and San Joaquin rivers and Tulare and Buena Vista basins.

The Reclamation Board may designate floodways throughout the Sacramento and San Joaquin rivers drainage basin to control encroachments in, and to preserve the flow regimens of, floodways for the purpose of protecting public improvements, lives, land use values, and improvements created in reliance upon historical flooding patterns.

Between The Reclamation Board and DWR, organizational changes including more budget and staff will be needed to meet the resource needs and commitments presented by the Comprehensive Plan. Currently, The Reclamation Board has only three permanent staff and DWR provides support to the Board for designated floodways, permitting, and project development. The addition of Board or DWR staff to oversee coordination of these efforts would improve Board efficiency as future projects are planned and constructed.

The Reclamation Board's Authority over Encroachments (California Water Code, Section 8608)

The board shall establish and enforce standards for the maintenance and operation of levees, channels, and other flood control works of an authorized project or an adopted plan, including, but not limited to standards for encroachment, construction, vegetation and erosion control measures. In adopting such standards, the board shall give full consideration to fish and wildlife, recreation, and environmental factors. Any violation of such adopted standards without the permission of the board is a public nuisance, and the board may commence and maintain suit in the name of the people of the state for the prevention or abatement of the nuisance.

Some of the day-to-day tasks will include ensuring:

- **Coordination with Agencies, On-going Programs, and Project Sponsors.** Continue project coordination with CALFED (including sub-programs) and other ongoing or future flood management and resource planning efforts in the Central Valley.
- **Public Outreach.** Continue public outreach and involvement to ensure the public is informed and actively participates in planning projects. Establish regional stakeholder groups to help ensure public engagement and problem solving.
- **Conflict/Policy Issues Resolution.** Facilitate resolution of conflicts that arise on flood management and ecosystem uses and functions within the flood management system. This may require formulation of new policies or recommendations for legislative action. Establish regional stakeholder groups to help ensure public engagement and problem solving.
- **Legislative Communication.** Prepare briefings and respond to legislative requests for information.
- **Budgeting.** Prepare annual budget requests for continued implementation under the Comprehensive Plan.
- **Studies/Planning.** Continue technical planning to develop projects and advance plan implementation. Staff will prepare project-specific documentation or oversee documentation prepared by others to bring projects on-line in accordance with the Comprehensive Plan and all applicable laws and statutes. Based on the results of project documentation and public support, advance specific flood management and ecosystem restoration projects for authorization and funding.

Implementation of future projects guided by the Comprehensive Plan presents many opportunities to assist in the accomplishment of the work of CALFED. These include opportunities to improve the integrity of the levee system and realize the CALFED Ecosystem Restoration Program goals and objectives; coordinate the development of additional flood control storage with additional storage for water supply; and realize water quality improvements with flood damage reduction and ecosystem restoration actions. Future projects should address species in the CALFED Multi-Species Conservation Strategy (MSCS), which identifies conservation goals, (such as "recovery," "contribute to recovery," and "maintain") for each species based on recommendations from Federal and State agencies and leading scientists.

- **Design/Construction.** Oversee necessary project refinements during pre-construction, engineering, and design conducted by any project proponent. The organization will track schedules and costs during construction of Corps/Reclamation Board cost-shared projects. They will also participate in decisions and data collection necessary for project refinements during construction.
- **Assessment and Modification of Future Projects.** Integrate adaptive assessment and management in the projects to determine how well they function and allow adjustments.
- **Permitting.** Work with project proponents to obtain necessary floodplain encroachment permits and other required permits.
- **Emergency Response.** Support DWR and Corps emergency response and coordination with other entities in accordance with California's Standardized Emergency Management System (SEMS) during flood emergencies and facilitate rehabilitation assistance following a flood.
- **Ecosystem Restoration.** Assist other agencies to restore the ecosystem in the floodplains.
- **Coordination of Operation and Maintenance (O&M).** Coordinate with maintenance districts on system operation and maintenance needs. This will include obtaining information on operation and maintenance of project facilities to aid in adaptive management and decisions on future project development.
- **Planning for Designated Floodways.** While recognizing that local government has primary responsibility for land use planning, assist local agencies in designation and planning within floodways. This could include establishment of new policies and programs for floodplain management.
- **Technical Evaluation and Model Maintenance.** Ensure technical evaluations and models developed for the Comprehensive Plan are updated as new project features are considered and brought on-line or as new information becomes available.
- **New Technical Evaluations and Models.** Ensure that, as technology advances and needs arise, new technical evaluations and models are completed. These technological improvements could include further enhancement of GIS capability.

Adaptive Assessment and Management

A science-based adaptive assessment and management approach includes the following components:

- Having clear goals and objectives for management that take into account constraints and opportunities inherent in the systems to be managed.
- Using conceptual models, in conjunction with hypotheses, that reflect current understanding of how natural and managed systems function.
- Selecting and implementing policies and programs that sustain or improve the production of desired ecosystem services while, at the same time, generating new kinds of information about ecosystem function.
- Selecting and implementing policies, programs and projects for flood damage reduction and ecosystem restoration.
- Development of monitoring protocols and remediation or management appropriate to the scale, opportunities and constraints of the individual project. This approach will rely on monitoring and evaluation of actions for all program planning objectives.
- Iterative management and modification of conceptual models and project planning and design.

- **Public/Agency Access to Technical Information.** Ensure access by interested parties to all technical evaluations and models as appropriate, ensuring no breach of security considerations.
- **Guiding Principle Application.** Ensure all Guiding Principles are applied consistently for each project.
- **Model Application.** Ensure consistent application of modeling tools to all proposed projects.
- **Use of Guiding Principles by Regulatory Agencies.** Ensure that regulatory agencies understand the Guiding Principles and, whenever possible, consider them during regulatory compliance efforts.
- **Promote Both Flood Damage Reduction and Ecosystem Restoration Projects.** Ensure balanced consideration for ecosystem restoration and flood damage reduction during project planning.
- **Partnerships.** Promote partnerships between flood damage reduction and ecosystem restoration project proponents. Partnerships would increase opportunities for dual-purpose projects.
- **Coordination with State, Federal, and Local Agencies.** Ensure adequate coordination with all agencies regarding projects proposed for planning and construction. The task would include ensuring pertinent entities are notified and included in the review process as appropriate.
- **Scientific/Peer Review.** Review (1) modeling and mapping tools, (2) proposed projects, and (3) success of established projects. A standing body of scientific experts will be maintained to facilitate these reviews and provide guidance on prioritization of projects.
- **Annual Report.** Consider preparation of annual reports to account for accomplishments under the Comprehensive Plan, including projects in partnership with CALFED and others.

Comprehensive Plan Implementation Issues

The Reclamation Board solicited input from policy issue focus groups to identify potential institutional barriers to Comprehensive Plan implementation. The process included identification of institutional barriers to implementation of floodwater and floodplain management features. However, the public expressed concern over the limited representation in the process coupled with inadequate time to identify and develop mutually acceptable solutions. This raised the need for a more broad-based approach for future work on the implementation issues. Two examples of implementation issues are listed below:

- Under existing law, participation of the Federal government in projects requires economic justification on a project-by-project basis. Federal participation requires a cost analysis be completed to show if benefits outweigh costs, which potentially limits solutions. The State also requires similar justification but has greater latitude in its justification. With significant differences in damageable property between the regions, it is unlikely that each region, or portions of a region, can justify the same level of flood protection. However, if the entire system could be justified as one project, there may be more opportunities for solutions.

- Although the benefits of flood management projects are distributed generally throughout the basin watersheds, the beneficiaries do not all share the costs for maintenance of the project facilities. Costs generally fall on the local maintaining agency immediately adjacent to those facilities. One approach to address this issue is to review existing local benefits and consider wider-reaching valley or regional-wide benefits and assessment district(s) that may include watershed lands contributing to storm runoff. Benefit areas could include regions for habitat restoration.

Federal Benefit/Cost Requirements

Although the topics of various benefits and costs for Federal water projects appeared in several earlier statutes, it was the Flood Control Act of 1936 that established the statutory requirement that benefits for Federal flood control projects shall exceed the costs. This requirement was subsequently applied to other water project purposes. Present Federal water and related land resources planning is guided by the Principles and Guidelines (P&G) that were approved in 1983 pursuant to the Water Resources Planning Act of 1965. The P&G provides a consistent Federal planning procedure, defines the Federal objective and interest, and leads to plans that are responsive to national, State, and local concerns. Details on how the Corps of Engineers applies the benefit-cost requirements during the planning process are given in Engineer Regulation No. 1105-2-100, Planning Guidance Notebook, dated April 22, 2000. Corps of Engineers' regulations and other documents can be found on the Internet at http://www.usace.army.mil

The process for identifying and resolving implementation issues will continue and will include all interested parties including environmental interests, property owners, flood management agencies, county agencies, and others throughout the two river basins. This process will begin with the advancement of the first regional project for study, but will have valley-wide participation and will consider both specific regional and system-wide implementation issues. The implementation issues process will be conducted in a manner that minimizes time and financial impacts to the participants. When necessary, the process will include professional assistance in conflict resolution.

Use of the Guiding Principles

The Guiding Principles are intended to provide “guidance,” not absolute “requirements” for future projects that affect the flood management system. The Reclamation Board is an appointed body that must openly debate the merits of each proposal, take public input, and make decisions on a case-by-case basis. The Guiding Principles are not intended to replace the discretionary authority of The Reclamation Board, but may be used to assist the Board in making consistent decisions that benefit the flood management system.

The Reclamation Board intends to apply the Guiding Principles whenever possible, but recognizes that there may be variability in how they are used. Not all Guiding Principles can apply equally to all projects. Not all projects have the same opportunities or responsibilities to satisfy the Guiding Principles. For example, reoperation of an existing reservoir for flood management would enhance public safety and help optimize the use of existing facilities, but would likely play little role in promoting effective floodplain management. A project that proposes to plant trees in a backwater area could avoid hydraulic impacts and use an ecosystem approach, but this purpose would likely have little to do with promoting multi-purpose projects. The complete set of Guiding Principles will probably be more applicable to regional projects due to the greater opportunities provided by their larger geographic scope.

Based on The Reclamation Board’s existing flood management authority, all projects must “recognize that public safety is the primary purpose of the flood management system” (first Guiding Principle) and must “avoid hydraulic and hydrologic impacts” (fourth Guiding Principle). Planning documents should discuss how proposed projects are consistent with the Guiding Principles. Proposed projects should not detract from any of the Guiding Principles. The following are examples on how the Guiding Principles can be applied, primarily based on opportunity. Discretion on their use remains with The Reclamation Board.

- **System-Wide Projects.** Many potential system-wide projects are non-structural in nature. For these projects, The Reclamation Board will likely look for the opportunity to apply all the Guiding Principles, but only a few are likely to be prominent for any project. At the same time, a system-wide project should not detract from any of the Guiding Principles. For example, the Enhanced Flood Response and Emergency Preparedness (EFREP) project could provide a new system-wide plan for flood forecasting, response, and preparedness to provide better flood warning. Public safety is the main reason for the potential project. The EFREP does not detract from the remaining Guiding Principles.

- **Regional Projects.** Most regional projects may result in physical changes to the flood management system. The Reclamation Board and the Corps will likely be participants in regional projects. The intent is to use all eleven Guiding Principles to guide regional project planning.

- **Local Projects.** Most local projects may result in physical changes to the flood management system, but due to their smaller geographic scope, fewer of the Guiding Principles are likely to be prominent. The Reclamation Board will encourage project enhancements and partnerships that expand the opportunities to satisfy the Guiding Principles, especially for projects involving CALFED or other State/Federal funding.

- **Applications for Encroachment Permits.** The Reclamation Board and its staff process numerous applications for encroachments within the floodways. These generally do not result in changes to the flood management system, so the Guiding Principles (other than the first and fourth) will not normally apply. Examples of encroachments would be a new irrigation pump or a new barn. Depending on the extent of a proposed encroachment, supporting documentation to evaluate potential hydraulic impacts and proposed mitigation may be required. The Reclamation Board General Manager normally approves applications that are consistent with Title 23 of the California Code of Regulations. Applications that require a variance, involve a protest, or present a sensitive situation go to The Reclamation Board for decisions. Actions outside the leveed reaches may require encroachment permits if they affect the flows within the leveed reaches.

The application of the Guiding Principles will likely evolve as The Reclamation Board gains experience with their use. In any case, the public can always present their views on how the Guiding Principles should be applied for specific projects on a case-by-case basis at the regularly scheduled Reclamation Board meetings.

Participation in New Projects

For Federal flood management projects in the Central Valley, the Corps normally is the Federal sponsor, The Reclamation Board is the non-Federal sponsor, and local districts, counties, or cities are the local sponsors. However, the project non-Federal sponsor may vary depending on the specific project and benefits provided. In some cases, the Corps may work directly with the non-Federal sponsors without the involvement of The Reclamation Board. In other cases, local entities may choose to work alone without direct involvement from the Corps or The Reclamation Board. Ecosystem restoration projects may also involve other agencies that have ongoing ecosystem responsibilities.

Flood management projects sponsored by the Corps are designed to ensure that a project provides a net benefit (benefits greater than costs) to the area, State and to the nation, that it complies with all applicable laws and regulations, will be operated and maintained by non-Federal entities, and it is supported locally. There is a specified process for identifying the alternative that maximizes net benefits and defines the extent of Federal participation. The Federal planning process is generally responsive to State and local needs. If the non-Federal partners' needs are different from those the Federal process would select, there are provisions for recommending a "Locally Preferred Plan" that may cost more or less than the alternative with the maximum net benefits.

In most cases, Congressional authorization is required to construct a project. Similarly, the State legislature would normally authorize and appropriate funding for the State's share of project construction. A feasibility report and environmental document are used as the basis for authorization. For flood damage reduction and ecosystem restoration projects, it is the responsibility of the non-Federal sponsor to provide all the lands, easements, rights-of-way, relocations, and disposal areas (LERRDs) necessary to implement the project.

The Comprehensive Plan will not change the provisions of existing laws governing Federal and State sponsored flood management projects.

- **System-wide Projects.** Subject to budgetary constraints and stakeholder interest, The Reclamation Board and the Corps intend to sponsor system-wide projects and to share equally in the cost of planning studies. However, some system-wide projects, such as new policies for floodplain management may only involve The Reclamation Board and local entities. Any required construction or other implementation required for system-wide projects will be based on standard Federal and non-Federal cost-sharing formulas. For most projects, the State would likely pay the entire non-Federal cost of the implementation. However, depending on the specific project, local cost-sharing or O&M may be required.

- **Regional and Local Projects.** Planning for regional and local projects can begin only when local entities identify a need and are interested in proceeding with project development. Depending on their interest, these local sponsors should take an active participation during technical studies and project planning. Typically, feasibility studies for regional and local projects would be shared equally between the Federal and non-Federal sponsors. Any required construction or other implementation will be based on standard Federal and non-Federal cost-sharing formulas. For construction, the local sponsors will normally pay between 30% and 50% of the non-Federal cost-share; the State can increase its share of the non-Federal construction cost from 50% to 70% for multi-purpose projects that provide environmental, recreational, or environmental justice values.

  Smaller rural areas, such as individual reclamation districts, may have difficulty providing a positive net benefit for flood damage reduction because of the relatively low property value to be protected compared to the cost of project construction and the associated mitigation. A project may be more beneficial if combined with a larger area to create a regional project that has efficiencies in cost and scale. Including ecosystem restoration benefits or other benefits, funded by others, such as water supply could increase net benefits for flood damage reduction.

A General Guide for Federal/State Sponsored Flood Management Projects

1. Local sponsor identifies the problems and initiates discussion with The Reclamation Board or Corps staff to evaluate the potential for State participation and/or requests in writing that the Board or Corps consider participation in studying the problems.

2. If The Reclamation Board agrees that the study should go forward, the Board requests Corps participation.

3. With Congressional direction and appropriation, the Corps conducts a reconnaissance study (up to $100,000) at 100% Federal cost to determine whether further study is warranted (economic viability and Federal interest).

4. If the study has a positive recommendation, the Corps and the non-Federal sponsor seek Federal and State authorization, respectively.

5. If there is Federal and State interest from the reconnaissance study and additional funding and legislative authorization, the Corps and non-Federal sponsor prepare a Feasibility Report and necessary environmental documentation as required by NEPA and CEQA. The study cost is shared 50% Federal and 50% non-Federal. The Feasibility Study determines the continued Federal interest; the benefits must exceed the estimated costs.

6. Congress may authorize construction of the project.

7. If the Reclamation Board is the non-Federal sponsor, the Board signs a Local Project Cooperation Agreement (LPCA) with the local sponsor(s) and a Project Cooperation Agreement with the Corps.

8. The cost of Pre-construction, Engineering and Design (PED) and Construction activities are typically shared 65% Federal and 35% non-Federal, with non-Federal interests responsible for all lands, easements, right-of-way, relocation and disposal sites.

9. The non-Federal cost is normally shared 50% State and 50% local sponsor except for multi-purpose projects where the local share can be reduced to 30% of the non-Federal cost.

10. After completion of construction, the project is transferred to the local sponsor for operation and maintenance.

Landowner Rights

Any project implemented under the Comprehensive Plan must comply with laws and policies requiring just compensation for any property used for project purposes. The Fifth Amendment to the U.S. Constitution states the Federal government must pay just compensation for private property needed for authorized public purposes. The Fourteenth Amendment applies this same principle to the States and their political sub-divisions. Additionally, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended, provides a series of policies that must be followed by an acquiring agency to protect the property owner in this process. It is the Corps policy to acquire the minimum real estate interest necessary to support a project.

The Reclamation Board does not intend to use eminent domain to acquire property solely for ecosystem restoration purposes. Existing laws and regulations also encourage every effort be made to acquire property through a negotiated agreement. However, there may be instances when it is necessary to use eminent domain to acquire property for the over-riding public interest. For the purposes of protecting public safety and reducing flood damages, The Reclamation Board will consider use of eminent domain if it were not possible to acquire all the properties by negotiated sales.

The Comprehensive Plan does not have the authority, interest, or intent to change present water rights. If water is required for project purposes, Corps regulations and policy state that the water rights are treated as LERRD cost, and provided by the non-Federal sponsor. Some concerns have been expressed that if lands along the river were acquired for project purposes, that the landowner could lose the riparian water rights associated with that property. Continued rights to this water can be specifically reserved in the property conveyance agreement so the landowner does not lose this water right.

Adaptive Assessment and Management

Modifying the Sacramento and San Joaquin River system requires an adaptive approach for learning and incorporating new information into the planning of future projects. The information can be used to help make adjustments if project performance needs improvement. Because of the inevitable uncertainties in large, complex ecosystems, natural and human systems will at times respond in ways that are not anticipated or predicted by any existing assumptions. Adaptive assessment and management provides a process to moderate or eliminate potential crises by providing early detection and a sequence of responses to follow.

An adaptive assessment and management program will be coordinated by the appropriate responsible entity (as defined by The Reclamation Board) to determine how well planning objectives are achieved and to adjust actions based on new information. Projects will be planned and constructed using a science-based adaptive assessment and management approach, which relies on setting measurable goals, developing conceptual models of expected responses from a completed project, constructing the project, and monitoring and evaluation actions for all planning objectives. This is an iterative process where information from the monitoring and evaluation is used to make needed adjustments to the projects. Specific elements to be included in the adaptive management and assessment program are:

- Physical and biologic processes of the riverine ecosystem.
- At-risk native species dependent on the watershed and other species that are good indicators of ecosystem health and success of habitat restoration.
- Performance of the flood management system.

Coordination with Ongoing Programs

Project planning and construction under the Comprehensive Plan will be coordinated with CALFED for ecosystem restoration and other CALFED objectives as appropriate. The Reclamation Board will conduct the coordination or ensure project proponents conduct the coordination. Project coordination actions are listed below:

> In support of the **CALFED single blueprint for ecosystem restoration**, the Comprehensive Plan will integrate those CALFED ERP goals, objectives, targets, and actions that can be accomplished through changes in the flood management system of the Sacramento and San Joaquin rivers. Non-Federal sponsor interest will ultimately determine which actions are implemented.

- Coordination with CALFED:
    - Coordinate projects with the CALFED policy and management groups, the Bay-Delta Public Advisory Committee, and their successors.
    - Integrate proposed ecosystem restoration projects and activities into the CALFED Ecosystem Restoration Program's ERP draft Stage 1 Implementation Plan, annual work plan/single blueprint for restoration, regional plans.
    - Develop all projects with the CALFED ERP's regional coordinators and with the habitat restoration coordinators of the CVPIA Anadromous Fish Restoration Program.
    - Report restoration project outcomes to CALFED's science and ecosystem restoration program to present and assess research findings and monitoring data and to measure progress towards the ERP's Multi-Species Conservation Strategy milestones.
    - Coordinate with the CALFED ERP's science program to ensure scientific review of conceptual models, hypotheses, and uncertainties associated with projects and drawing, to the extent feasible, on advice from CALFED's Independent Science Board.
    - Coordinate new surface and groundwater storage development with CALFED's Storage Program.
    - Coordinate flood flow and stage conditions within the Delta with CALFED's Levee System Integrity Program.
    - Participate in Agency/Stakeholder Ecosystem Team and Bay-Delta Public Advisory Committee.

- Coordinate San Joaquin River basin projects with the San Joaquin River Management Program (SJRMP).

- Coordinate upper Sacramento River basin projects with the Sacramento River Conservation Area Forum (SRCAF).

- Coordinate with the State's Floodplain Management Task Force.

- Coordinate projects within the CVPIA area of influence with the U.S. Bureau of Reclamation (USBR).

- Coordinate with other programs and projects as appropriate.

Wildlife-Friendly Agricultural Practices

Stewardship practices and incentives for wildlife-friendly agriculture are currently being evaluated and enacted by other agencies. Where appropriate, flowage and conservation easements could include provisions for wildlife-friendly agricultural practices. Wildlife-friendly programs would be administered by other agencies than The Reclamation Board. Agricultural practices could include the following:

- Establish a self-sustaining perennial border, shelterbelt, or riparian buffers.
- Plant wildlife food-plots or leave stubble or a portion of a crop unharvested for wildlife.
- Delay fall tillage to allow waste seeds and grains for wildlife.
- Practice integrated pest management to reduce chemical pesticide use and save money.
- Create tailwater ponds to capture sediment and improve water quality.
- Manage harvested rice fields for straw decomposition and wintering water birds.
- Schedule farming activities to avoid disturbance of nesting birds.
- Consider many other specific programs/incentives to improve wildlife food and shelter and reduce stressors.
- Establish good grazing practices.

Wildlife Friendly Agriculture provides opportunities for both the conservation of agriculture and enhancements to wildlife from changes to agricultural practices.

Conservation easements can help prevent human encroachment on agricultural lands. A growing number of incentive programs are available to assist landowners in establishing conservation easements. It is estimated that the net return on investment from a conservation easement is equivalent to selling the land for development (American Farmland Trust, 2001).

Wildlife-friendly agricultural practices conserve soil, improve water quality and quantity, and increase or improve habitat for desired wildlife species. Such practices must make economic sense to landowners. Several agencies offer grants, cost sharing programs, or technical assistance for wildlife enhancement projects. Landowners can also diversify their income by establishing duck clubs, dry land hunting, and bird watching.

"Good Neighbor" Management

Efforts are underway by agencies and organizations to better define how wildlife habitat management can be done in a manner that is friendlier to surrounding agricultural land. These include ways to manage such things as weeds, flooding, erosion and trespassing. Buffer strips adjacent to the agricultural land offer one way to reduce these potential impacts to agricultural land. Implementation of new projects under the Comprehensive Plan will consider ways to improve "good neighbor" management, including providing commitments in the operation and maintenance manuals.

Floodplain Management

The State of California is responsible for pursuing the floodplain management program improvements. In an effort to reduce the impacts of flooding through better coordination of floodplain management, Assembly Bill 1147, signed into law in 2001 by Governor Davis, recommended establishment of a Floodplain Task Force. The California Floodplain Management Task Force was established in early 2002 and held its first meeting on April 19, 2002. It is examining specific issues related to State and local floodplain management, including actions that could substantially reduce potential flood damages and to make recommendations for more effective state-wide floodplain management policies. The Reclamation Board in a member of the Task Force. The Task Force will complete its work by December 31, 2002, and report its findings to the Governor.

The California Floodplain Management Task Force includes members from private, non-profit, and local interest groups and State, Federal, and local agencies. Each member is involved in making recommendations to the Governor for more effective statewide floodplain management policies while representing their respective community or group. The Task Force will evaluate the challenge of developing fair, comprehensive, and coherent policies for floodplain management.

Floodplain management can provide early and lasting benefits well before the longer lead-time regional projects can be developed. One factor in meeting the Plan's goals is recognizing the prominent roles that ecosystem and agriculture play as compatible floodplain uses. The recommendations of the Task Force will be evaluated as appropriate for incorporation into the Comprehensive Plan and all future projects.

Future Technical Studies

Individual projects must complete appropriate technical studies to ensure good planning, engineering, and design. These studies may include:

- Geotechnical and levee alignment studies.
- Geomorphology and river meander studies.
- System-wide coordinated reservoir reoperation studies on both river basins.
- Increased reservoir storage concepts and coordinated reoperation with other Sacramento and San Joaquin basin reservoirs.
- Updating the system-wide hydrology and hydraulics models. The Corps and The Reclamation Board will maintain the models as funding allows.

- Ecosystem Function Model refinements in conjunction with site-specific project planning.
- Defining the general location, type, and extent of effects to be evaluated as part of a cumulative impacts analysis.

While the Comprehensive Study's computer models provide an unprecedented capability to evaluate the operation of the flood management system, the models will require periodic updates using best available information. Planning for each regional project will provide new opportunities for updating the existing models or developing new models as needed. The local interests, the Corps, The Reclamation Board, and other partners should work together to select data and models for the specific project. In some cases, only modification to input data such as flood flows may be required. For some projects, the existing models may need to be modified to reflect changed physical conditions or operational rules. New site-specific models may be needed for some areas to provide greater definition for project design. Continued active participation by the local sponsors throughout project planning, design, and construction will facilitate overall project development and O&M.

Climate Change

Recent scientific study suggests that projected climate changes would affect hydrologic conditions in the study area. Flooding problems may worsen due to anticipated effects which include more rapid rainfall runoff, less snow pack, increased sea level, and changes in the timing, frequency, duration, and intensity of storms. The high dependence on reservoir storage and snow pack for flood management and water supply make the State of California particularly vulnerable to these types of projected hydrologic changes. While specific estimates of these changes have not been quantified, future project modifications should consider the ability to adapt to changing climatic conditions. Impacts and uncertainties of climate change should be taken into account when water management systems are evaluated for future changes to improve flood management, ensure effective ecosystem restoration, and increase overall system flexibility. Information obtained from coordination between water agencies and leading scientific organizations to advance the understanding of climate changes and impacts on water resources will be incorporated to periodic plan updates as it becomes available. A wider range of climatic conditions will be considered in project evaluations to reduce system vulnerability and long-term costs.

Measuring Project Performance

There are a number of ways to compare alternative projects and to measure performance once a project is constructed. The planning objectives provide a basis for developing evaluation criteria for comparison and for measuring project performance. While these planning objectives apply generally to the Comprehensive Plan, additional regionally or locally-specific objectives may be developed for more detailed planning of future projects. Potential measures of success for each of the planning objectives are as follows:

1) Reduce the risk to human life, health, and safety due to flooding.

- Decrease depth of flooding.
- Decrease frequency of flooding.
- Increase flood emergency warning time.
- Preserve evacuation routes.
- Decrease velocity of floodwaters.
- Decrease duration of flooding.
- Decrease levee failure potential.
- Reduce the amount of infrastructure or human development in the floodplain.

2) Promote natural dynamic hydrologic and geomorphic processes.

- Increase flow variability (including frequency, depth and duration of flooding) to support natural geomorphic and biological processes, including releases leading to non-damaging flooding that is safely contained within the natural floodplains or the flood management system.
- Provide a river system that could support ecosystem restoration without increasing flood stages to levels that threaten flood management system reliability.
- Provide a river system that has sufficient floodway width and minimizes the need for hardened structures and provide a channel meander/migration zone of sufficient scale to allow the expression of natural geomorphic functions, including bar formation, channel migration, and avulsion.
- Increase the system-wide number of floodplain hydrologic features (such as oxbows, sloughs, and side channels) reconnected to floodway.
- Provide conditions throughout the system necessary for sediment mobilization, transportation and deposition required to establish and maintain channel and floodplain morphology. This includes ensuring the upstream supply of coarse sediment needed to sustain geomorphic processes and related habitats.

3) Reduce damages due to flooding.

- Decrease residual risk of flooding.
- Improve regulation of development in floodplains.

- Improve design standards for floodplain structures.
- Decrease depth, duration, and frequency of flooding of structures.
- Decrease velocities of floodwaters.
- Reduce the amount of infrastructure or human development in the floodplain.

4) Increase and improve the quantity, diversity, and connectivity of riparian, wetland, floodplain, and shaded riverine aquatic (SRA) habitats, including preservation of agriculture and its ecological value.

- Protect or manage quality of existing remnant forest, aquatic, and wetland habitats within flood management system in order to maintain ecosystem benefits.
- Increase area of riparian, wetland, and floodplain habitats.
- Increase extent and connectivity of SRA habitat.
- Increase application of wildlife-compatible agricultural practices.
- Minimize conversion of floodplain agricultural land to urban/suburban uses and maintain open space buffers.
- Increase habitat connectivity to support characteristic flora and fauna and maximize the ecological richness of the aquatic and terrestrial interface.
- Increase habitat interspersion.
- Increase habitat structural diversity.

5) Minimize the flood management system operation and maintenance requirements.

- Decrease operation and maintenance costs.
- Decrease costs associated with erosion repair and protection, including flood fighting.
- Decrease vegetation control requirements.
- Reduce conflicts with environmental protection requirements, including those for endangered species that inhibit the ability of levee maintenance districts to consistently accomplish required maintenance.
- Decrease emergency response costs and risks to rescue personnel.
- Plan for and provide a buffer of vegetation between flood management structures and the river to increase reliability and reduce maintenance costs.
- Improve means to protect existing levees, where needed, in a manner which is environmentally acceptable.

6) Promote the recovery and stability of native species populations and overall biotic community diversity.

- Increase the quantity and quality of habitat suitable for listed, at risk, and/or sensitive native species.
- Increase populations of listed, at risk, and/or sensitive native species.

- Increase biotic community diversity.
- Decrease competition from non-native, invasive species.

Projects

Projects can be proposed by any entity. During evaluations conducted for the Comprehensive Study, three potential projects generated significant stakeholder interest:

- **The Enhanced Flood Response and Emergency Preparedness Project.** A feasibility-level study is underway between the Reclamation Board, the Corps, and regional, as well as local stakeholders.
- **The lower Sacramento River Regional Project.** Stakeholders are organizing regional and local interest in planning a regional project for the lower Sacramento River area. This will be done in cooperation with the State and Federal governments.
- **The Hamilton City Flood Damage Reduction and Ecosystem Restoration Project.** Local stakeholders have requested the State complete detailed feasibility-level studies for a flood damage reduction and ecosystem restoration project.

Updates

This report has been prepared as an *Interim Report* so it can be updated as needed in the future. The concept is to have an updated version of the *Interim Report* available each time a project is moved forward for State and Federal authorization. In this way, the new information on system-wide findings, the Comprehensive Plan, implementation information, and new information on the progress/accomplishments will provide the context for how a proposed project fits within the complete system. In the absence of such projects triggering an update, an update should be prepared at least every six years.

Technical Review of Projects

In the exercise of their authority to regulate activities in designated floodways that affect performance of the flood management system, The Reclamation Board now has tools that can evaluate the system-wide effects of proposed changes to the system. The hydrologic and hydraulic models developed by the Comprehensive Study can determine if a proposed action will impact how floodwaters move downstream through the river system and floodplain. These models will also provide the means to determine the effectiveness of mitigation actions. When linked to the basin-wide economic models, any predicted change in how floodwater moves through the system can be translated into changes in the distribution and magnitude of monetary flood damages.

Financing

Since projects could be planned and constructed by any agency or private entity, numerous different funding sources and mechanisms could be used. Local agency or private entity participation would proceed with their own funding sources. State participation could proceed with authorization and appropriations from the State Legislature and from State water bonds. Federal participation in new project planning and construction could require authorizations from Congress and would require future appropriations or could rely on continuing authorities for small projects. Local, State, and Federal agencies often work together on project planning and construction.

Planning and construction of projects would be greatly facilitated with a State and Federal discretionary funding account. The account could provide funding of local projects that contribute to flood damage reduction and ecosystem restoration objectives of the Comprehensive Plan. State and Federal authorization of an account for such projects could provide the mechanism to advance these projects in a more timely and efficient manner. The account could be budgeted based on anticipated use. A future recommendation for a similar account could be considered in State and Federal authorizations if local sponsors become interested in enough specific local projects to warrant such a program.

Regulatory Compliance

Since the Comprehensive Plan describes only a general process for project planning, no programmatic environmental documentation is required. The current Comprehensive Plan described in this document sets forth a framework for balanced and well-coordinated flood management and ecosystem restoration projects within the study area. It does not identify project actions with enough specificity to allow for the evaluation of individual project and cumulative impacts at this time. As specific projects are advanced within the Comprehensive Plan framework, the cumulative impacts will be evaluated through a programmatic EIR/EIS or through the cumulative impact analyses associated with each project.

Specific projects planned and constructed under the Comprehensive Plan will be supported by appropriate NEPA and CEQA documents. Each project advanced for construction will need to comply with all applicable Federal and State laws, regulations, Executive Orders (EO), and policies. While there are a great number of Federal, State and local laws and policies that must be discussed in a NEPA/CEQA document, the most relevant laws and permits include the Federal and State Endangered Species Acts; the Clean Water Act, the Porter Cologne Act, Fish and Wildlife Coordination Act, the Clean Air Act; the National Historic Preservation Act, and the Historic and Archeological Resources Protection Act; and EO 11988 Flood Plain Management, EC 11990 Protection of Wetlands, and EO 12898 Environmental Justice.

In addition, there are several laws and programs that deal with issues or resources that are very important to large segments of the population in the project area. These laws include, but are not limited to, the Farmland Protection Policy Act, the Land and Water Conservation Fund Act, the Open Space Lands, the Williamson Act, the American Indian Religious Freedom Act, and the Indian Trust Policy. The projects and actions that will be considered as part of the Comprehensive Plan will also be evaluated to assure consistency with applicable CALFED programs. All studies and projects are subject to all current rules, policies, regulations and laws.

Interim Flood Management System Needs

Because it will take decades for projects to be constructed, several existing activities need to continue for public safety in the interim. Consideration of the Guiding Principles may provide opportunities to improve the activities.

- **Emergency Flood Fighting.** Emergency flood fighting and rehabilitation work should recognize and implement modifications of the system where possible.

- **Operation and Maintenance.** Guiding Principles may help resolve conflicts between private interests, agencies with lands or regulatory jurisdictions within the floodways, and those doing maintenance. Joint operation and maintenance, for both flood management and habitat restoration, should make use of the Guiding Principles to both improve maintenance and minimize costs. However, without modifying the system, opportunities for joint operation and maintenance are limited.

- **Streambank and Levee Erosion.** The Sacramento River Bank Protection Project (SRBPP) will likely only be able to do streambank protection where levees are eroding and likely to fail and local sponsors have financing to participate in the effort. The Guiding Principles may help guide mitigation efforts. SRBPP authority may terminate before system-wide and regional projects are constructed in the Sacramento River Flood Control Project. Some authority or extension of authority to include ecosystem restoration to address issues relating to streambank erosion is likely needed until system-wide and regional projects can be implemented. Research should continue on developing acceptable options to protect levees from erosion.

- **Land Use.** Local and State governments need to be responsive and coordinate land use priorities and associated flood risk and ecosystem needs as well as agricultural and urban changes for a more sustainable environment.

- **Infrastructure.** Infrastructure changes involving transportation and other vital public and private uses should not preclude options for future flood management and ecosystem restoration.

- **Floodplain Management.** The Reclamation Board will need to utilize the technical models and analyses developed by the Comprehensive Study in conjunction with the Guiding Principles to evaluate floodway encroachments within their jurisdiction. Agencies involved in floodplain management should utilize the best data available as well as maintain and improve upon the technical models. The concept of residual risk should be fully considered in all floodplain management decisions. FEMA Flood Insurance Rate Maps should be periodically updated with the new models and an improved understanding of the flood management system gained from technical studies.

- **Encroachment Permits.** The Reclamation Board will continue to process applications for encroachments within the floodways.

Potential System-Wide Measures

Potential system-wide projects generally focus on better management of the existing system. They could be approached separately from potential regional projects or could be incorporated into each future potential regional project as needed.

The extent of shared public views on needs and expectations defines the extent of projects. System-wide support would mean a basin-wide project. System-wide projects have potential to yield more total benefit for less individual cost. An example is the Enhanced Flood Response and Emergency Preparedness project where no single county alone is able to install additional rain gages throughout the basins. All counties are working together with the State and Federal governments to complete this public safety project. Following is a partial list of potential measures for use in system-wide projects.

Enhanced Flood Response and Emergency Preparedness

The existing flood response and emergency preparedness system for the Sacramento and San Joaquin River basins includes the State of California and Federal institutions, staff, procedures, and equipment for detecting and responding to floods. The Enhanced Flood Response and Emergency Preparedness project (one of several “initial projects” in previous reports) is a new system-wide plan to review components of the existing Federal/State forecasting, flood response, and preparedness system and identify opportunities for enhancement. Flood response and preparedness includes data collection and transmission, a data filing and displaying system, an integrated evaluation system, an information dissemination system, and system-wide preparedness plans. Objectives for the plan are to reduce the risk to public safety and flood damages by increasing warning time and improving data reliability. The Enhanced Flood Response and Emergency Preparedness plan can provide early benefits while other projects are being planned.

Floodplain Management Program Improvements

Rather than reducing the probability of flooding, floodplain management programs seek to reduce the flood damages experienced by people and property by encouraging sustainable land use decisions and protecting structures already within the floodplain.

By making better land use decisions, more open space (agriculture and native habitats) could be maintained. Specific actions cannot be identified in advance of development of regional projects, but evaluations have shown that a range of improvements may be appropriate. The State is looking at the feasibility and implementability of such actions for expanding existing programs. Examples of potential actions include:

- **Risk Based Flood Mapping.** This feature includes mapping and identification of flood hazard areas in the Central Valley to improve communication of flood risk, forecasting, warning, augment floodplain mapping programs and information systems, and expand real estate disclosure requirements to include residual flooding risk.

- **Flood Hazard Mitigation for Existing Development.** This feature includes identification and mitigation of flood-prone lands including measures such as:
  - Acquire land or flow easements at key floodplain locations from willing sellers.
  - Relocate, raise, or flood-proof structures on a voluntary basis.
  - Implement alternative storm water management techniques.
  - Improve funding for and encourage activities that potentially have the most long-term effectiveness, such as watershed-based management and planning.
  - Improve flood hazard mitigation grants programs.
  - Establish a proactive outreach and education program on the benefits of multi-objective floodplain management principles for local agencies.

- **Flood Hazard Mitigation for New Development.** This feature includes measures to mitigate damages to future development:
  - Encourage local entities to account for flood risk during land use planning within the floodplain.
  - Regulate storm water runoff from new development to avoid increasing flows to downstream channels.
  - Provide a hydraulic impacts bank by creating a funding source to mitigate hydraulic impacts of future projects that affect the flood management system. The bank could be used when projects within the flood management system are unable to mitigate hydraulic impacts within the project boundaries. The bank could also be used to mitigate increased runoff from individual developments within the watershed. The funds could be used to help pay for downstream conveyance improvements, direct compensation to affected jurisdictions, or to purchase easements on designated flood prone areas similar to the bypasses.
  - Provide environmental mitigation banks to consolidate habitat mitigation rather than allowing many smaller unconnected mitigation areas.
  - Plan for transitory storage and conveyance programs.
  - Plan for habitat restoration and other multi-objective floodplain projects.
  - Develop and maintain evaluation tools (hydrology/hydraulics, GIS, and other models) to support the program.
  - Provide incentives to communities, in the form of hazard mitigation grants, for a broad array of non-structural measures such as controlling floodway encroachments.
  - Expand the NFIP by extending the potential for flood insurance in areas beyond the 1-in-100 risk of flooding in any year and basing the insurance rates on the flood hazard and residual risk. Graduate the insurance premiums based on actuarial risks within the floodplain.

- **Other Potential Floodplain Management Measures.** Several other measures to support floodplain management practices have been identified:
  - Public education to provide an awareness of the value of floodplain lands as open space that preserves agricultural uses and ecosystem functions.
  - Development of floodplain management practices in rural areas requiring the implementation and enforcement of land use ordinances by local entities that restrict land use to those commensurate with the flood risk.
  - Development of a program that includes financial incentives for landowners to practice good floodplain management.
  - Development of floodplains for rural areas in a way that generates support from local, State, and Federal agencies.
  - Consider revising general plan governing statutes for floodplain management to require onsite detention to achieve no net loss of floodplain storage or no net increase in runoff from development. Some, but not all, communities already have a similar policy.
  - Clarify State floodplain management policy and coordinate responsibility.
  - Clarify the national floodplain management policy and coordinate responsibility.
  - Improve funding for and encourage activities that potentially have the most long-term effectiveness, such as watershed-based management and planning.
  - Develop information and awareness programs.
  - Institute flood protection planning taking potential flood patterns and frequency of inundation into account. Areas able to endure most floods with little damage require less flood protection than areas with highly damaging flood patterns. Moreover, farmlands able to withstand flooding with little damage may be suitable sites for temporary flood storage.
  - Consider establishing a higher (such as 1-in-200 risk of occurring in any year) minimum level of flood protection standard for urban areas.
  - Encourage the State to consider adoption of local floodplain management plan requirements similar to the Federal requirements to supplement requirements in the Hazard Mitigation Planning and Hazard Mitigation Grant Program (2002) and Governor's Executive Order on floodplain management.
  - Act to ensure compliance with recently-enacted building codes, such as the ASCE Standard 24-98 to encourage communities to assist with the transition from disaster recovery to disaster prevention.
  - Encourage local ordinance to require that structures with substantial flood damage potential be flood-proofed in accordance with building codes as a prerequisite to issuing a building permit.
  - Develop river corridor management plans to guide flood management, ecosystem and public access throughout the system. These plans would be developed in cooperation with area stakeholders.

System-wide Reservoir Reoperation

Reservoir reoperation is aimed at a more efficient operation of existing facilities to maximize their benefit and reduce the need for structural modifications to the system. More efficient reservoir operation may be possible if structural modifications can be made to the dams or reservoirs. (Structural modifications, such as new outlets or spillways, could be considered for future projects). In addition, since system-wide reservoir reoperation would provide more efficient flood operations, it would not require significant downstream modifications to be implemented first. Reoperation would not alter current water supply commitments without appropriate mitigation and compensation, but could provide some water supply benefits depending on the selected operation. The reoperation improvements could include developing a detailed reservoir operation plan including the following components, where appropriate:

> The reservoir reoperation project is intended to reoperate flows only during the flood season. Depending on the needs of local sponsors, the project could consider releases during other times to benefit other uses.

> Depending on the schedule for regional projects, reservoir reoperation may be considered as one system-wide project or included as a component of each regional project.

- **Coordinated Reservoir Reoperation Analysis.** This element would optimize operational coordination between two or more reservoirs based on target flows for common downstream control points.

- **Anticipatory Reservoir Release Analysis.** This element would provide reservoir pre-releases (vacating the flood pool earlier based on improved storm forecasting).

- **Operation of Headwater Reservoirs for Flood Management.** This element would formally operate existing headwater reservoirs, currently operated primarily for water supply and hydropower, for flood management purposes.

- **Modifying Reservoir Releases for Ecosystem Benefits.** This element would modify reservoir floodwater releases to benefit the riverine and floodplain ecosystems through actions such as changes in draw-down timing and ramping rates for reservoir releases.

- **Conjunctive Use for Flood Management.** Conjunctive use (cooperative management of both surface water and groundwater resources) for flood management involves lowering reservoir storage level below the flood management pool and transferring this displaced water to groundwater storage. This transfer vacates additional flood pool space in the reservoir for use in intercepting flood flows, while conserving transferred water in another location for later, beneficial use. This would be locally controlled and could be incorporated into ongoing or future conjunctive use projects.

- **Use of Existing Drainage and Water Supply Conveyance Facilities.** This analysis should evaluate the costs, benefits, and impacts associated with using existing or expanded agricultural supply and drainage facilities to convey floodwaters.

Multipurpose Floodway Maintenance

Floodway and levee maintenance is becoming more difficult due to increasing conflicts with environmental regulations and increasing costs. Channel maintenance is generally a DWR responsibility whereas reclamation, levee and flood control districts usually maintain the levees. Currently, maintenance is based on needs for flood management with habitat preservation primarily resulting from regulatory requirements. The maintaining agencies do not generally have adequate funding for multipurpose maintenance. Additional maintenance funding could be generated from a region-wide or valley-wide assessment district or governmental participation. A new maintenance approach, without compromising public safety, could be developed on a system-wide basis or incorporated into the plans for the regional projects and could include one or more of the following:

- **Research and Incorporate New Maintenance Practices.** New research could develop "best management practices" for maintaining the flood management system, including ecosystem restoration and preservation features. While a self-sustaining ecosystem is preferred, ecosystem maintenance will be required in places to retain system flood carrying capacity. The best management practices would provide guidance to maintaining districts to meet the needs of the varied river and habitat conditions throughout the system. One example technique for some areas could be the use of "prescribed fires" in floodways to decrease vegetative understory. This practice may reduce floodway roughness, reduce maintenance costs, and encourage specific desirable habitats.

- **Modify Operation and Maintenance Manuals.** Modification of operation and maintenance (O&M) manuals and the project purpose could include criteria to accomplish dual uses of channels, levees, and other flood management facilities for flood management and ecosystem restoration and preservation. Maintenance for environmentally-sensitive areas could require special guidance.

- **Modify Encroachment Permits.** The encroachment permits could be modified to require the applicant to maintain both flood management and ecosystem purposes. Funding assistance could be provided when ecosystem restoration is incorporated into an existing district's flood management maintenance responsibilities.

- **Provide Mitigation Credits.** New mitigation credits could allow habitat growth with additional operation and maintenance costs paid for by others. This is similar to private mitigation banks now being used for urbanization impacts.

- **Multipurpose Operation and Maintenance Funding.** Funding for both flood management and ecosystem preservation/restoration could be obtained from valley-wide assessment areas, grants, or other sources not currently being used.

- **Redesign Flood Management Facilities.** The redesign of the flood management facilities for flood damage reduction and ecosystem restoration would require additional changes to the existing standard O&M procedures. This could require a modification of existing O&M manuals or production of new O&M manuals. The maintenance criteria on a reach basis could identify specific maintenance requirements that could accomplish the multiple uses of channels, levees, and other flood management facilities for flood management and habitat preservation. The regulatory agencies could be partners in developing the criteria so as to minimize conflicts and set agreements on maintenance practices for both flood management and habitat preservation.

These items should be more fully developed, on a site-specific basis, with input from resource agencies, stakeholder groups and the levee, flood control, and reclamation districts responsible for the maintenance. The opportunities for these procedures will likely increase as the existing flood management system is modified.

Potential Regional Measures

Following is a partial list of potential measures for use in regional and local projects to reduce flood damages and restore the ecosystem. A measure is any activity or physical feature that could be implemented at a specific geographic site to achieve desired objectives. Depending on local stakeholder needs, measures can be combined in various ways to create alternative plans. To develop a regional or local project, alternative plans can be evaluated and compared to assess potential beneficial and adverse effects, estimate costs, and weigh tradeoffs. Any proposed project would be designed and constructed to maintain the integrity of the flood management system. Additional measures may be identified during future studies for regional or local projects.

Storage Measures

- **Modify Reservoir Operations.** Improve reservoir operations to more effectively manage floods and to contribute to ecosystem restoration. The reservoir operation measures described under Potential System-Wide measures could be conducted with many reservoirs at the system-wide scale or with a few reservoirs at a regional scale.

- **Use of Water Delivery Systems to Store Floodwaters.** Some existing water delivery systems are currently used to divert and move floodwaters to groundwater recharge areas. An expansion of this practice could move more water to storage areas. In addition, canals that currently operate only during irrigation could be used during floods to move water for temporary storage on certain agricultural lands, such as rice fields. This could benefit the flood management system by redirecting reservoir releases and improving the operational flexibility of the flood management reservoirs. The temporary storage of water on agricultural lands could also offer considerable benefits to wintering waterfowl and shorebirds.

- **Use Storage Space in Headwater Reservoirs for Flood Management.** By coordinating operations of headwater reservoirs with flood control reservoirs for flood management purposes, these reservoirs could potentially increase the effective flood management pool and increase operational flexibility. Any increase in flow would provide opportunities to make releases more favorable to the ecosystem.

- **Modify Release Capacity of Dams.** Increasing the release capacity of dams could improve the flexibility and effectiveness of flood management operations. Increased outlet capacity would allow reservoirs to be evacuated more quickly in anticipation of large inflows. Additional release capacity could be provided through spillway modifications or construction of new outlet works. The increased release capacity could also be used for releasing pulse flows to restore ecosystem functions.

- **Increase Reservoir Storage.** Additional reservoir storage capacity could improve flood management in the system and increase operational flexibility. Additional reservoir storage could be provided by raising existing dams or by constructing new reservoirs. This storage could benefit flood management, provide instream flows for biological resources to partially offset adverse impacts of the dam and reservoir, and provide new water storage. Off-stream reservoirs are normally located on relatively small or intermittent streams and are primarily filled by diversions from other rivers or transfers from other reservoirs in the system. On-stream reservoirs directly capture flood flows. New on-stream reservoirs are not consistent with the CALFED ecosystem restoration objectives and are not being pursued by CALFED in their investigations of new water storage opportunities. Multipurpose reservoirs could benefit flood management, provide instream flows to benefit the ecosystem, and provide new water supply.

- **Increase Conjunctive Use for Flood Management Storage.** Most reservoirs with flood management storage are drawn down during the flood season to provide space for floodwater. Allowing a larger draw down would allow the reservoir to capture more floodwater, but could reduce water supply if the reservoir did not refill by the end of the flood season. Providing new conjunctive uses of groundwater and surface storage space could allow a larger flood storage pool in the surface reservoir and avoid loss of water supply by increasing storage in groundwater.

- **Establish Transitory Floodplain Storage.** During flood peaks, this measure would direct floodwater out of the river and onto adjacent floodplains where the floodwater could be stored temporarily and then released back into the channel once the flood peak had passed. Overflow weirs could be constructed to regulate floodwater entering the storage areas from the rivers and their tributaries. Construction of levees could be used to limit the area of flooding. Return flow strategies would minimize the entrapment and stranding of aquatic species. Easements on lands in the transitory storage area would be properly acquired with adequate compensation for flood-flow attenuation, agricultural production, passive and/or active habitat restoration, and possibly groundwater recharge purposes.

Conveyance System Measures

- **Construct New Levees.** Constructing new levees to protect landside development from flooding may be appropriate in some areas that are currently without levees. These could include ring or extension levees to protect small communities or other isolated flood prone development. Where existing channel capacity limits the opportunity to allow riparian growth within the floodway, new levees could increase the opportunity for habitat restoration.

- **Raise Levees.** Raising the height of existing levees could increase the conveyance capacity of the flood management system and/or allow for the increased development of riparian vegetation within the floodway.

- **Realign Levees.** Relocating levees at specific locations where existing levees create constrictions in floodplain width and/or are at risk of failing due to erosion and bank failure could improve conveyance capacity, reduce water surface elevation, improve ecosystem functions, create new waterside areas for habitat restoration, reduce flow velocities, and decrease the need for expensive bank protection. The realignments may allow channels to meander within specified limits, thereby providing additional floodplain areas for the development of riparian habitat. In addition, realigned levees could reduce the threat of levee failure and increase storage, which attenuates flood flows. Relocating levees from the river to a point where levee foundation material would be sound would reduce the risk of levee failure.

- **Strengthen Levees.** Strengthening levees could promote public safety and reduce flood damages. Rehabilitating or strengthening existing levees could provide a high level of flood protection to areas where there are few opportunities to modify the existing floodway. An existing levee could be rebuilt in place to meet current standards, providing the foundation under the levee is adequate. A water barrier, such as a slurry wall, could be constructed into the levee to prevent seepage. The levee waterside cross-section could be enlarged or a berm could be added to allow for the vegetation to reduce erosion. And provide ecosystem benefits. Vegetation management could be minimized without threatening levee safety or reliability.

- **Establish Meander Zone.** Creating a meander zone, where feasible, through acquisition of lands and easements could promote the natural succession of vegetation, except where bank protection is needed to protect critical project levees and bridges and to maintain flow splits to flood relief structures. The river could meander freely within the limits of the zone. This would establish a natural channel configuration based on available flows and would provide additional floodplain areas for the development of riparian and SRA habitat and restore the functioning of natural ecosystem processes. This would allow continuation of the use of land for agriculture, recreational access, and enhancement and preservation of environmental qualities. Floodway easements, conservation easements, or other easements could be purchased in these meander zone areas. The widened floodway would also lower water levels and attenuate flood flows, thereby contributing to reduction of flood flows.

- **Modify Weirs.** Weirs could be modified to divert a larger portion of flood flows from the rivers and into the bypasses. This could be accomplished by lengthening the weir and/or lowering sections of the weir. New flowage easements may be required depending on how flood flows in the bypass were affected by changes to the weir. Diverting more water into the bypass could lower water surface elevations in the river channel downstream from the diversion, increasing the level of flood protection and allowing for changes in management practices that would permit more natural development of riparian vegetation where public safety is not compromised.

- **Increase Bypass Capacity.** The conveyance capacity of bypasses could be increased to accommodate additional flood flows. This measure would likely be implemented in combination with modifications to weirs. Modifications could include changes to the height or alignment of the existing levees or constructing a backup levee system. Realigning the existing levee could provide ecosystem benefits by increasing the area of floodplain habitat and allowing for increased development of riparian habitat within the floodway.

- **Minimize Flow Constrictions and Obstructions.** Flow constrictions along the rivers or in the bypasses could be minimized to reduce stage and increase conveyance capacity. This could involve modification of railroads, highways, and/or other facilities that cross the flood management system. Stage reduction could reduce restrictions on development of native vegetation, thereby increasing ecosystem benefits.

- **Modify Bypasses to More Effectively Convey Small Flood Events.** A system could be constructed within bypasses to convey small flood events that do not inundate the entire bypass. Managing small flood events would protect agricultural operations and managed wetlands from damage caused by late season floods that tend to be smaller and more frequent. The system could also improve drainage of agricultural lands in the fall and spring. The frequency and duration of small events could be increased in a portion of the system to provide more reliable floodplain habitat for native fish and ecosystem restoration benefits.

- **Breach Levee.** Opportunities for breaching levees, apart from where setback levees are also constructed, are very limited and can only be done in areas where the natural topography will reasonably confine flood flows. Opportunities for levee breaches would first be identified on public lands. The benefits of breaching levees for flood damage reduction and ecosystem restoration are similar to the benefits of widening the floodway by realigning levees, as discussed previously. Lands in this widened floodway could be managed for a combination of agricultural production and passive and/or active habitat restoration.

- **Develop a Flood Overflow Corridor or High Flow Bypass.** This measure would consist of constructing new high-flow bypasses to prevent flood damages, which may be particularly applicable in the rapidly developing South Delta area. Some existing levees could be strengthened to improve conveyance and backup levees could be constructed on the landside of existing project levees to create the “bypass” area. Overflow weirs could be constructed to regulate floodwater inflow and outflow from these areas. Floodway easements, conservation easements, or other easements could be purchased in these new bypass areas. Incorporating restoration and recreation, where appropriate, with sustained agriculture and compatible floodplain land uses could be included in this measure. Increased system capacity could reduce channel maintenance requirements for vegetation control, thereby increasing riparian habitat within the floodplain.

- **Develop Side Channels.** Where the floodway is constrained, preventing the long-term sustainability of natural channel migration and vegetation succession, developing side channels and providing a water supply could preserve existing habitat and increase riparian diversity. Developing side channels through excavation of the enclosed floodplain or through deepening of existing remnant side channels could help attenuate flood flows. Developing either flowing channels or dead-end channels for standing water could redirect water. Depending on the topography of the site, implementing several variations of this measure, such as (1) connecting side channels to the river at the downstream ends to allow backwater inflow from the river, (2) constructing controlled inlets at the upstream ends designed to withstand flood flows and retaining the riverside levee for protection from flood flows, and (3) grading other lands between the levees to provide a range of elevations above the expected water table and establishing a mosaic of riparian vegetation types could be included. Any of these variations would be designed and constructed to maintain the integrity of the flood management system.

- **Restore Oxbows.** At abandoned oxbows with flat gradients, grading small areas to allow flooding during high and moderate flows could provide ecosystem restoration opportunities such as planting with tules, sedges, and other emergent marsh vegetation, as well as various willow and cottonwood species. Expanding productive habitats beneficial to waterfowl and perching-bird habitat (like the yellow-billed cuckoo) could be a benefit of the measure.

- **Revegetate Wetland and Riparian Habitats.** Restoring riparian and wetland habitat on lands within the existing and expanded floodways, both along rivers and in the bypasses, could benefit fish and wildlife and improve habitat connectivity. Opportunities for restoring habitat would first be identified on public lands and then through conservation easements, land acquisition in fee title, or programs for voluntary retirement of agricultural operations within the floodway. Riparian revegetation improves fish habitat conditions for successful spawning of winter-run Chinook salmon and other salmonids. Plants on the banks aid channel stabilization and provide increased wildlife habitat. Plant cottonwoods and willows along the river and into the floodplain as appropriate. Use nursery stock or wildlings (local cuttings) where ground water is close to the surface or where irrigation is planned.

- **Reduce Fish Stranding.** Fish stranding can occur within the floodway along rivers and in bypasses when flows drop and fish are not able to get back to the river. Stranding could be reduced through physical changes to the system. Inactive gravel mining and borrow pits could be reconnected to the river or filled-in to prevent fish stranding after high flow events. Fish passage facilities could be constructed to permit upstream migration from bypasses back to the river.

- **Reconstruct River Channel.** Reconstructing the river channel could restore channel capacity. In areas that have had high rates of sediment deposition, the excavation of a channel may be necessary as part of a larger effort to restore the continuity of the river.

- **Manage Sediment Input from Agricultural Return Flow.** This measure proposes creation of off-stream ponds and wetlands that capture agricultural return flow and allow sediment and contaminants in the water to filter out before discharging into the rivers. The water could be slowly released into the river and the ponds periodically drained and cleared of sediment.

- **Dredge Sediment**. Accumulated sediment within the river channel could be removed to reestablish low flow channels in several areas. Sediment could be removed periodically by dredging to restore and maintain channel capacity.

- **Modify Levee Maintenance.** Modifying existing maintenance practices that require clearing of vegetation from levees could allow for more native riparian vegetation. Vegetation could provide protection to levees from rain-caused surface erosion on slopes and from wave wash and erosion on waterside slopes.

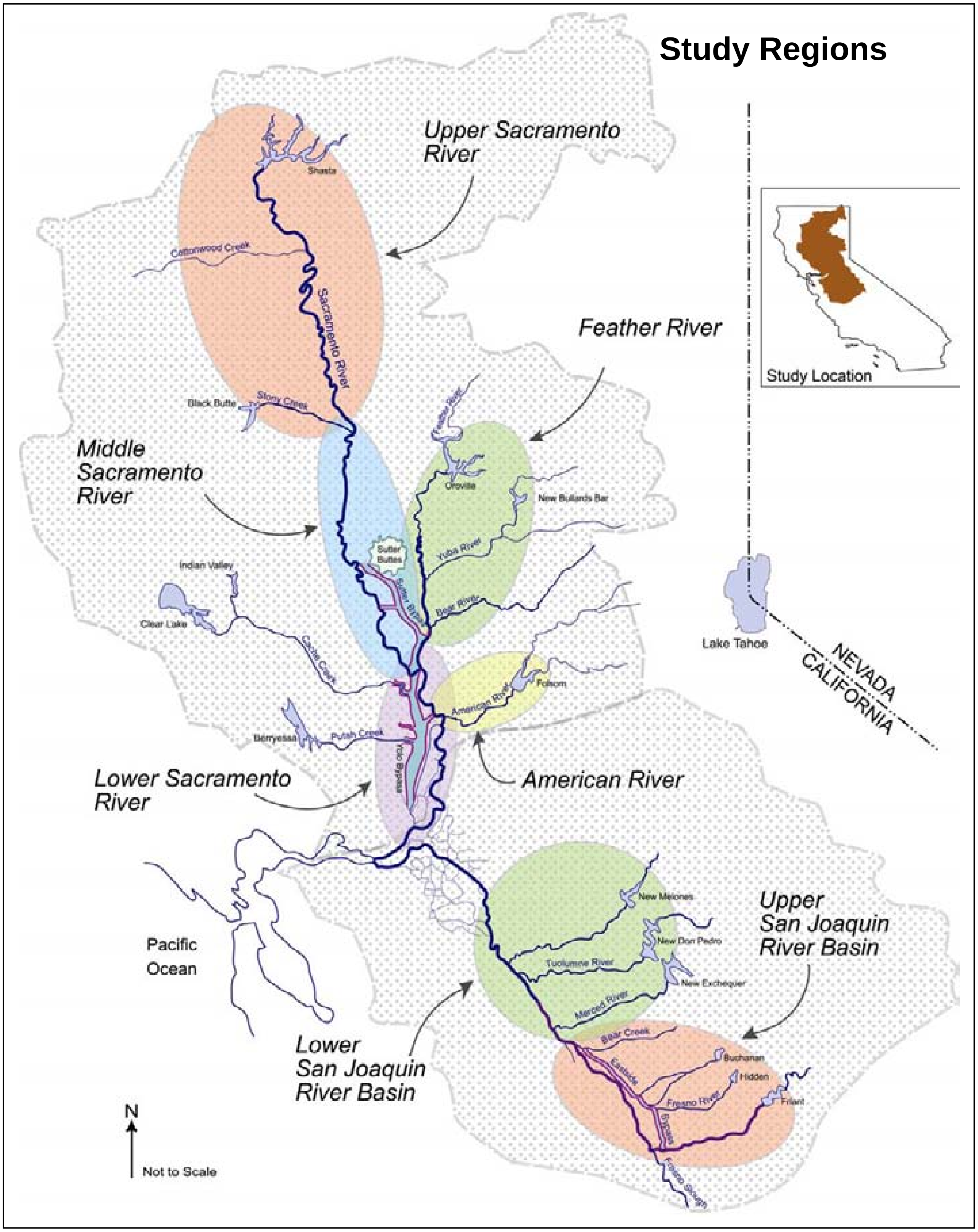
Regional Descriptions

The Reclamation Board will coordinate with all ongoing and future project development efforts to ensure the most recent information is used and that the Guiding Principles are applied.

Currently, there is strong interest in new projects in some regions. Joint local, State, and Federal projects for the American River region are at various phases of planning and construction. Similarly, there is a joint local and State study underway to increase flood protection to Yuba City and Marysville in the Feather River region. In the lower Sacramento and lower San Joaquin River regions, some stakeholders have expressed support for future flood damage reduction and ecosystem restoration projects in cooperation with State and Federal agencies.

Before a regional project can be developed for the middle Sacramento River region, the collection of additional levee geotechnical data is essential. In some regions, there are ongoing water resources investigations that may change regional water storage facilities and flow regimes that, in turn, will affect flood damage reduction and riverine ecosystem restoration opportunities. For the upper Sacramento and the upper San Joaquin River regions, there are important investigations underway by CALFED, USBR, DWR and other stakeholders to determine if additional water supply storage in those regions is feasible.

The following sections are descriptions of each of the study regions shown in the following figure.


Study Regions
Upper Sacramento River
Shasta
Cottonwood Creek
Sacramento River
Black Butte
Stony Creek
Feather River
Study Location
Middle Sacramento River
Oroville
New Bullards Bar
Yuba River
Sutter Buttes
Indian Valley
Clear Lake
Bear River
Cache Creek
Lake Tahoe
NEVADA
CALIFORNIA
Folsom
American River
Berryessa
Putah Creek
Yolo Bypass
Lower Sacramento River
New Melones
Upper San Joaquin River Basin
New Don Pedro
Pacific Ocean
Tuolumne River
New Exchequer
Merced River
Bear Creek
Lower San Joaquin River Basin
Buchanan
Hidden
Fresno River
Friant
N
Not to Scale

Upper Sacramento River Region

The upper Sacramento River region is bounded by Shasta Dam in the north and Chico Landing in the south, a distance of about 118 river miles. The Sacramento River drains the Klamath Mountains at the northern end of the Sacramento Valley near Mount Shasta. The McCloud and Pit Rivers join the Sacramento River in what is now Shasta Lake, a reservoir created by Shasta Dam.

The geomorphology of the Sacramento River varies throughout the region. From the base on Mount Shasta for about 75 miles downstream to near elevation 300 near the town of Red Bluff, the river is generally constrained from moving laterally by erosion-resistant volcanic and sedimentary formations. The river in this area, the Sacramento Canyon, is generally narrow and deep, and the floodplain is similarly narrow. From here, the river emerges onto the broad alluvial floodplain of the Sacramento Valley. For the next 50 river miles or so, the Sacramento River historically meandered freely across a wide floodplain. By eroding and depositing sediment, the river migrated across deep alluvial soils from the Red Bluff area to about Hamilton City and Chico Landing.

Shasta Dam provides flood protection to the nearby communities of Redding, Anderson, Red Bluff, and Tehama, as well as the agricultural lands, industrial developments, and communities downstream along the Sacramento River. Private levees or low berms limit the area of flooding in both urban and agricultural areas. Nevertheless, small communities and portions of larger communities continue to be at risk of flooding along portions of the river and tributaries. Shasta Dam is operated for an objective release of 79,000 cfs at Redding and 100,000 cfs at Bend Bridge in Red Bluff. Flows greater than 36,000 cfs begin to cause flooding in Redding. The Keswick Dam release needs to be restricted to this level for as long as the release schedule on the Flood Control Diagram allows. In the spring, even moderate release increases can affect agricultural diversion weirs that, quite often, are in place by April. Usually, the diversion structures lower the non-damaging release value to about 15,000 cfs, less than 20 percent of the objective release of 79,000 cfs.

Tributaries entering the Sacramento River from the west, including Clear, Cottonwood, Elder, Thomes, and Stony Creeks, drain runoff from the Coastal Mountain range. Cottonwood Creek provides the most significant amount of inflow to the Sacramento River in this region. Tributaries from the east drain runoff from the Cascade and Sierra Nevada mountain ranges including Cow, Bear, Battle, Paynes, Antelope, Mill, Deer, Rock, and Big Chico creeks. Most of the tributaries are unregulated and can contribute high flood flows to the Sacramento River.

The maximum historical flows from Keswick Dam to Red Bluff are predominantly a result of the uncontrolled local drainage. The 2,500-square mile uncontrolled drainage area between Keswick Dam and Bend Bridge can produce flows well in excess of the design channel capacity of 100,000 cfs. These high-magnitude flows can occur very rapidly, requiring release changes from Keswick Dam based on official flow forecasts and complicated by the 8- to 12-hour travel time between Keswick Dam and Bend Bridge.

The Chico Landing to Red Bluff Project, authorized in 1958, extends and modifies the Sacramento River Flood Control Project. This project, sponsored by The Reclamation Board, provides for bank protection (erosion protection) and incidental channel modifications along 50 miles of the Sacramento River between Chico Landing and Red Bluff. In this reach, 21.5 miles of bank protection have been installed to hold the river in place and prevent meandering of the channel. Erosion from meandering channels causes damages to agricultural lands. The project also calls for floodplain zoning along the river upstream to Keswick Dam to limit development and maintain a floodway area to carry maximum flood management releases from Shasta Lake safely.

Vegetation in the region includes cottonwood forest, mixed riparian forest, riparian scrub, and valley grassland. The existing habitat in this region is in relatively good condition. However, human disturbance has contributed to the decline in the abundance and condition of riparian habitats within the upper Sacramento region.

The region corresponds to approximately the northern one-half of the total river length. The Sacramento River Conservation Area Forum (SRCAF) has worked since 1986 to develop a management plan to protect, restore, and enhance both fisheries and riparian habitat along the Sacramento River between Red Bluff and Colusa. The plan provides guidance to agencies that may affect these resources and to private property owners who may wish to contribute to these goals through voluntary participation. The SRCAF provides a process to review agency proposals for consistency with the plan, facilitate coordination with others, and expedite regulatory review. The SRCAF does not implement elements of the management plan.

The hydrologic operation of Shasta Dam has disrupted physical processes in this reach of the river. In addition, bank protection has been installed to inhibit channel movement, and private levees, or low berms, have severed the Sacramento River from its floodplain. Large quantities of sand and gravel are being mined at locations in and adjacent to the Sacramento River and its tributaries. Barriers to fish passage exist in the main channel. Impacts from these activities on flows and sediment supply have had significant impacts on ecosystem processes in the upper Sacramento River region and contributed to the loss of fish and wildlife habitat, including the reduction of SRA habitat.

Currently, a total of 194 special status species have the potential to occur in this region; 34 are listed under FESA or CESA and 79 are included in the CALFED MSCS. Since these numbers were determined from a preliminary database search, the actual locations and numbers will not be accurately known until specific projects are proposed and biological field inventories are conducted.

There is an opportunity to use upstream flood management reservoirs to improve flood management reliability and to make strategic releases that support a more natural hydrologic regime. This could improve flood protection, improve recruitment of riparian vegetation and restore ecosystem functions. There is an opportunity to coordinate with CALFED and USBR in the study to increase storage at Shasta Reservoir. Conclusions of that study may result in needed changes to the flood management storage space at Shasta Reservoir, reservoir outflow, and flows in the downstream flood management system. There is also an opportunity to coordinate with

DWR in their investigation of the potential of additional off-stream storage for water supply at Sites Reservoir and other locations in their North of Delta Off-Stream Storage Investigations. There is potential that an off-stream facility could be designed to include flood management space. There is further opportunity to coordinate with the SRACF to contribute to achieving their goals.

Opportunities exist in this region to work with Federal, State and locally-held lands that have either been purchased for habitat restoration or have conservation easements. There is also an opportunity to purchase conservation easements on other lands within the floodway to improve floodplain habitat and to improve the connectivity, diversity, and extent of native riparian habitat. An opportunity also exists to develop partnerships between agriculture and the ecosystem by implementing both wildlife-friendly agricultural practices and “good-neighbor” wildlife management practices. These actions could also benefit conditions for migratory fish through the creation of additional SRA habitat.

Middle Sacramento River Region

The middle Sacramento River region is bounded by Chico Landing to the north and Fremont Weir to the south, near the confluence of the Sutter Bypass, Feather River, and Sacramento River. The region includes the towns of Butte City, Princeton, Colusa, Grimes, Knights Landing and Verona. This stretch of the Sacramento River is about 100 miles long and is paralleled by Sacramento River Flood Control Project levees. Flood flows from the Sacramento River spill into the Butte Basin downstream of Chico Landing through a series of overflow areas located at natural low points along the east side of the river. Further downstream, additional flood flows are diverted out of the Sacramento River into the Butte Basin and Sutter Bypass via the Moulton, Colusa, and Tisdale weirs. The Butte Basin empties into the Sutter Bypass. The Sutter Bypass, in turn, conveys flows to the lower Sacramento River region at the Fremont Weir near the confluence with the Feather River and into the Sacramento River and the Yolo Bypass.

About 10 miles south of Hamilton City, two tributaries merge with the Sacramento River -- Stony Creek from the west and Big Chico Creek from the east. From this point downstream, flood flows along the Sacramento River historically split between the main channel and adjacent basins that parallel both sides of the river; the Colusa Basin to the west, and Butte and Sutter basins to the east. These basins, which are lower than the river level, were separated from the river by natural levees. During high flows, water escaped from the main channel through sloughs or over low spots in the natural levees and filled the adjacent basins. The basins acted as natural reservoirs that attenuated flood flows by storing excess water. Some of this water later drained through sloughs and channels to the lower Sacramento River and Delta. The rest evaporated, percolated to groundwater, or remained in the bottom of the basins supporting great expanses of tule marsh. Because of the historic effect of the overflow basins in reducing high flows within the river channel, the Sacramento River actually becomes smaller in the downstream reach between Colusa and the mouth of the Feather River.

The Sacramento River flood management system was generally designed to accommodate this natural pattern of flood flow, with some modifications that have adapted the system to water and land uses since the late 1800s.

The historic hydrology and hydraulics of the Sacramento River have been greatly affected by the construction of flood management levees, bank protection placement, and dam construction. The levees and bank protection have restricted the river movement downstream from Chico and modified overflows to the natural flood basins during high flows. Overflow to the Colusa Basin was blocked by levees for protection of agricultural lands.

Downstream of Chico Landing, floodwaters in the Sacramento River overflow the east bank of the River into the Butte Basin. The purpose of the Butte Basin overflow areas is to provide a split of flood flows between the basin and the Sacramento River channel such that flows in the river do not exceed channel capacity. The Federal flood management project envisioned in the 1950s included a flood bypass through the Butte Basin. This component was not included due to economic issues.

Levees along the Sacramento River near Chico Landing to Colusa are generally set back from the river. Between Colusa and the Fremont Weir, the levees are set close to the river. The existing levee system is, in many places, built on poor foundations and constructed of substandard materials. Some stakeholders are concerned that there are not good foundations near the river for new levees. They are also concerned that since the land generally slopes away from the river, new levees away from the river may be too high and take too much land.

The Colusa Basin Drain roughly parallels the Sacramento River to the west, conveying flows from the Coast Range's westside tributaries to either the Sacramento River near Knights Landing, or to the Yolo bypass through the Knights Landing Ridge Cut. The Ridge Cut is an artificial channel that allows some drainage of flood water from the Colusa Basin Drain when the Sacramento River level is high. The Knights Landing Outfall Structure controls the direction of flows out of the Colusa Basin Drain and also prevents the backwater from the Sacramento River into the Drain.

Sediment transport, erosion, and deposition have changed since the current system was originally designed. Erosion is currently a major problem, contributing to the degradation of the Sacramento River channel and the erosion of the levee system. Erosion and scour of the Sacramento River channel may be causing toe failures of rock bank protection along miles of the river. To address this erosion problem, Congress authorized the Sacramento River Bank Protection Project. This action has resulted in a continual process of attempting to counteract the natural forces of the river through placement of miles of rock bank protection.

Shaded riverine aquatic habitat has been significantly reduced because of the placement of rock bank protection. The SRCAF has worked to develop a management plan to protect, restore, and enhance both fisheries and riparian habitat along the Sacramento River between Red Bluff and Colusa.

Currently, a total of 167 special status species have the potential to occur in this region; 32 are listed under FESA or CESA and 75 are included in the CALFED MSCS as potentially occurring in this region. Since these numbers were determined from a preliminary database search, the actual locations and numbers will not be known until specific projects are proposed and biological field inventories are conducted.

Levees along the Sacramento River from Chico Landing to Colusa that are already set back from the river offer greater flexibility in accommodating flood management, agriculture, and ecosystem restoration. The floodways in this reach have significant ecosystem restoration potential because they are large and subject to seasonal inundation and other natural processes that support ecosystem functions. An opportunity exists to develop a partnership between agriculture and the environment by implementing a long-term easement program, wildlife-friendly agricultural practices and "good-neighbor" wildlife management practices. Opportunities exist in this region to work with Federal, State and locally held lands that have either been purchased for habitat restoration or have conservation easements. Opportunities also exist in this region to purchase conservation easements on other lands within the floodway to compensate growers for managing agricultural lands in a manner that is more compatible with maintaining healthy fish and wildlife habitat, including strategic improvements to the connectivity, diversity, and extent of native riparian habitat. These actions would benefit conditions for migratory fish through the creation of SRA habitat.

There are opportunities to widen selected reaches of the floodways to relocate levees to better foundations, reduce constrictions and flow velocities, increase flow capacity, and restore ecosystem processes. Reducing floodway constrictions in this region would reduce the need for bank protection, improve levee reliability by reducing flood stage, and increase the opportunity for riparian habitat within the floodway.

Feather River Region

The Feather River region is a major tributary system to the Sacramento River, merging with the Sutter Bypass and Sacramento River near the Fremont Weir. The region includes the Feather, Yuba, and Bear rivers and their tributaries. The region extends from the headwaters of these rivers and tributaries to the Fremont Weir. Two major flood management reservoirs are located within the region, Oroville on the Feather River and New Bullards Bar on the Yuba River.

Yuba City and Marysville collectively make up the largest urban area in the Feather River region, with over 50,000 residents. One out of every four people in the region is employed in agriculture or a related service industry. Sutter County is consistently listed among the most productive agricultural counties in the nation.

Early efforts to manage flooding in the Feather River Basin were primarily directed toward building local levees to protect agricultural lands, leading up to construction of large dams and reservoirs in the mid 1900's. The Sacramento River Flood Control Project includes approximately 160 miles of levees within the Feather River Basin. Unlike much of the Sacramento River, the levees along the Feather and Yuba rivers are generally set back from the channel, forming wide floodways. Subsequent Federal projects, including Phase II of the Sacramento River Flood Control Systems Evaluation and the Sacramento River Bank Protection Project, and emergency assistance programs have provided assistance for reconstruction and strengthening of various reaches of levees within the Feather River Basin.

The Feather River generates flow greater than 300,000 cfs during large flood events. Several dams within the Feather River Basin regulate this flow and serve multiple purposes including flood control, water supply, hydropower, debris impoundment, recreation, and fish and wildlife. Oroville Dam, the tallest dam in the nation, has a storage capacity of over 3.5 million acre-feet. New Bullards Bar Dam has a capacity of nearly a million acre-feet, but controls runoff from less than 40 percent of the Yuba River watershed. Marysville Dam, planned for construction on the Yuba River to complement New Bullards Bar Dam, was authorized by Congress in the Flood Control Act of 1966, but was never constructed due to environmental concerns and the lack of State support. There are more than 20 headwater reservoirs that provide water supply, hydropower, debris impoundment, and recreation, but which are not operated specifically for flood management.

Several rural residential communities are located in low-lying basins that can experience rapid flooding with depths greater than 20 feet in the event of a levee failure. Peak flow records were set in 1986 prompting the evacuation of 24,000 people when a levee break caused widespread flooding in areas that included the communities of Linda and Olivehurst. The January 1997 flood event caused a levee break on the Feather River, two levee breaks on the Bear River, and several dike breaks on the Yuba River, causing loss of life and prompting the evacuation of almost 50,000 residents. Millions of dollars were spent defending, reconstructing, and improving levees during and following the 1986 and 1997 flood events.

Rivers in the foothill and lower basin areas have been severely affected by rapid aggradation caused by hydraulic mining activities. Since the ban of hydraulic mining in 1893, many channels have since incised into the debris. Natural and constructed debris impoundments remain both within the channels and in overbank areas. The lower Bear River is a single channel river that is characterized by low sinuosity and channel degradation over the last century. The lower Yuba River, which received significantly more mining debris than the Bear River, is characterized by high terraces of mining sediment alongside a degrading river channel with a steep gradient. Degradation has been accelerated along the lower Yuba River by dam construction and the gradual movement of sediment and mining debris down the Feather River.

Deposition of mining sediments transformed the Feather River into a wide and shallow channel characterized by sandbars and low sinuosity. The Feather River still receives significant sediment from the Bear River during flood events, but sediment inputs from the Bear River and other tributaries are declining, which could result in increased bank erosion and channel migration in the future. The lower Feather River experiences sediment deposition primarily caused by backwater from the Sacramento River and flow area expansion at the confluence with the Sutter Bypass.

Both seasonal and permanent agriculture is prevalent between levees of the Feather, Bear, and Yuba rivers. Because these areas remain connected with the river, they experience seasonal inundation, thereby providing valuable fish and wildlife habitat. Outside the floodways, the region has experienced significant urban development within the last decade. While agricultural lands cannot match the quality or diversity of native habitat, these lands provide an environmental resource in the study area. Consequently, the gradual conversion of agricultural land to urban development has impacted the wildlife that relies on these areas for foraging and nesting.

Prior to construction of the flood management system, the Feather River historically overflowed toward the west during major flood events, mingling with flood flows in the Butte and Sutter basins. The flood management system has had significant effects on the extent, distribution, establishment and survival of riparian and wetland vegetation and migratory fish.

The California Department of Fish and Game manages the Feather River Wildlife Area, which is comprised of lands along several miles of the lower Feather River floodway. The Feather River Hatchery, downstream from Oroville Dam, recovers anadromous fish that migrate up the Feather River. Anadromous species present in the Feather River include spring and fall run Chinook salmon, steelhead trout, green and white sturgeon, American shad, and striped bass. The South Yuba River and the Middle Fork of the Feather River are part of the California Wild and Scenic River System.

The Yuba River provides valuable spawning and rearing habitat for several species of anadromous fish, including American shad, striped bass, fall and spring run chinook salmon, white sturgeon, and steelhead trout. Habitat conditions in the lower Bear River, below Camp Far West Reservoir, are generally not favorable for resident rainbow trout or anadromous fish. Spawning in the Bear River is severely limited by silted spawning gravels and high water temperatures.

Currently, a total of 125 special status species have the potential to occur in this region; 23 are listed under FESA or CESA and 38 are included in the CALFED MSCS as potentially occurring in this region. Since these numbers were determined from a preliminary database search, the actual locations and numbers will not be known until specific projects are proposed and biological field inventories are conducted.

As the largest tributary system to the Sacramento River, improvements in the Feather River region would yield benefits outside the region and contribute to system-wide goals of the Comprehensive Plan. The Feather River region is unique in that there are many opportunities to reduce flood damages and improve the ecosystem without major modifications to the existing flood management system.

Levees along the Feather, Yuba, and Bear rivers that are already set back from the river offer greater flexibility in accommodating flood management and ecosystem restoration. There are opportunities to widen selected reaches of the floodways to reduce constrictions, increase flow capacity and restore ecosystem processes. Reducing floodway constrictions along the lower Feather River would improve levee reliability in the Marysville-Yuba City urban area by reducing flood stage and could increase the opportunity for riparian habitat within the floodway.

The floodways of the lower Feather River and lower Yuba River also have significant ecosystem restoration potential because they are subject to seasonal inundation and other natural processes that support ecosystem functions. Opportunities exist in this region to manage agricultural lands in a manner that is more compatible with maintaining healthy fish and wildlife habitat, including strategic improvements to the connectivity, diversity, and extent of native riparian habitat. These actions would benefit conditions for migratory fish through the creation of SRA habitat. These opportunities would support CALFED and the Anadromous Fish Restoration Program (AFRP) objectives in the Feather River region.

There are opportunities to improve the effectiveness of existing reservoirs in managing floods on the Feather, Yuba, and Bear rivers. The level of flood protection provided by Oroville and New Bullards Bar reservoirs could be increased by reoperation or physical improvements to the dams. Operational criteria could be modified to allowing greater flexibility to coordinate releases from Oroville and New Bullards Bar or accommodate forecast-based operations (also termed pre-releases). There are also numerous water supply and hydropower reservoirs upstream from Oroville and New Bullards Bar reservoirs that could be used to increase effective flood storage capacity of the region and provide greater operational flexibility during flood events.

There are also opportunities for existing flood management reservoirs to support CALFED ecosystem restoration goals by making strategic releases that reflect a more natural hydrologic regime. Over time, this would improve recruitment of riparian vegetation and could help form deeper, more natural channels. FERC re-licensing proceedings for Oroville Dam could also be a forum to address water temperature needs for anadromous fish. Removing debris impoundments that block fish migration and restoring riverside gravel mining pits that can strand fish could attain additional fisheries and aquatic habitat benefits.

Providing public access to the river for recreation while protecting private property is an important local issue, and opportunities to accomplish this should be considered in future projects.

American River Region

The American River region contributes significant flows to the lower Sacramento River region. Folsom Lake is the only reservoir with dedicated seasonal flood storage on the American River. Folsom Lake has a capacity of 977,000 acre-feet with a 400,000 acre-feet flood management reservation. A second multipurpose dam on the American River, Auburn Dam, was authorized in 1965, but was never completed due to political and environmental opposition. There are an additional 54 reservoirs in the American River watershed that provide hydroelectric generation and water supply but have no specific flood management responsibilities.

Planned and constructed projects address problems in this region. Because this region is well documented in other reports, this Interim Report does not further describe the American River region.

Lower Sacramento River Region

The lower Sacramento River region is located in the southern portion of the Sacramento Valley. The lower Sacramento River flows into the Sacramento-San Joaquin Delta. The region includes the Sacramento River downstream from the Fremont Weir, Yolo Bypass, Fremont Weir, Sacramento Weir and Bypass, and lower reaches of tributary streams.

The upstream end of the study reach is defined by the confluence of the Sacramento River, Feather River, and Sutter Bypass. The American River is the only major tributary to the lower Sacramento River. Downstream from Folsom Lake, the American River travels through the Sacramento metropolitan area and enters the Sacramento River in the City of Sacramento, considerably increasing the volume of flow in the Sacramento River. Downstream from the American River, the Sacramento River flows southwesterly for an additional 60 river miles to its terminus at Suisun Bay. While the volume of flow in the Sacramento River system generally increases as it moves south toward the Delta, the size and capacity of the Sacramento River historically decreased in the downstream direction. Flood flows spilled into adjacent flood basins that were separated from the main stem by natural levees. The sheer magnitude of flood flows that entered these adjacent flood basins created several distributary flood paths across the flat valley floor into which the mainstem would spill. The Yolo Basin, west of Sacramento, and the American Basin, northeast of the confluence of the Sacramento and American Rivers, are two of these historic overflow basins. The lower end of the Yolo Bypass and the Sacramento Deep Water Ship Channel, which runs along the east levee of the Yolo Bypass, are controlled by tidal backwater. Minor tributaries flowing into the west side of the Yolo Bypass include Cache Creek, Willow Slough, Knights Landing Ridge Cut and Putah Creek. Numerous distributaries flow through the low-lying tidal area of the Delta.

Land uses in the Sacramento River region are principally agricultural and open space, with urban development concentrated in and around the City of Sacramento. More than half the region's population lives in the greater metropolitan Sacramento area.

The lower Sacramento River region includes key components of the Sacramento River Flood Control Project (SRFCP). The Fremont Weir, at the upstream end of the region, controls the movement of large volumes of floodwater from the Feather River, Sacramento River, and Sutter Bypass, dividing flood flows between the Yolo Bypass and the lower Sacramento River. The Sacramento Weir controls movement of flows from the American River and divides them between the Yolo Bypass and the lower Sacramento River. Over 600,000 cfs can flow through the region during large flood events. This region is critical to planning efforts throughout the Sacramento River basin because it has the potential to affect the operation of weirs and bypasses in the entire SRFCP.

The only reservoir within the lower Sacramento River region with a flood management purpose is Indian Valley Dam and Reservoir on the North Fork Cache Creek. This reservoir has a capacity of 300,600 acre-feet with a 40,000 acre-feet flood management reservation. Major reservoirs that influence flows in the lower Sacramento River include Folsom on the American River, Oroville on the Feather River, New Bullard's Bar on the North Yuba River and Shasta on the upper Sacramento River.

The lower Sacramento River and Yolo Bypass discharge into the Delta. At high river stages, the Sacramento River can affect water surfaces throughout much of the Delta. At low river stages, the tidal influence extends up the Sacramento River as much as 80 miles to Verona and induces backwater in the Yolo Bypass. This interaction between the Delta and the lower Sacramento River region poses flood management constraints because any increase in river flood stage has the potential to impact hundreds of miles of Delta levees. However, it also offers unique ecosystem conditions favorable to the development of diverse and rare habitats such as tidal wetlands.

The lower Sacramento River is a single-channel watercourse with moderate to low sinuosity that is confined by levees located immediately adjacent to the riverbanks. The gradient of the river channel is relatively low and flat and becomes more so as it approaches the Delta. Sediment is generated from upstream reaches of the Sacramento River, tributaries, and bank erosion. Sediment deposition occurs most notably in the Yolo Bypass and Delta. The lower Sacramento River is a perched system, meaning that ground elevation generally decreases with distance from the river. This is due in part to historic (prior to hydraulic mining) sediment deposition that occurred more rapidly alongside the river than in the adjacent floodplains, forming natural levees and gradually elevating the river channel.

The Sacramento Valley along the rivers was historically dominated by riparian forest. Narrow remnants of riparian growth are located intermittently along the riverbanks and waterside berms of the lower Sacramento River and in parklands adjacent to the river. Plant communities along the Sacramento River include Valley oak riparian, cottonwood riparian, mixed elderberry savanna, oak woodland, freshwater marsh, seasonal wetlands, and grasslands. Migratory fish utilize the lower Sacramento River to reach upstream spawning and rearing areas, but their numbers have greatly decreased due to the construction of dams and other barriers on the tributaries.

The Yolo Bypass consists of a 59,000-acre, mostly leveed, floodplain within the greater Yolo Basin, a historic flow path to the Delta. Hydric soils within the bypass indicate that wetlands were dominant before the area was reclaimed for agricultural purposes. Historic wetlands in the Yolo Basin included semi-permanent shallow lakes, wet meadows, and tule marshes. Today, wetlands in the bypass are highly managed and located on private and public lands. Private wetland owners have created artificial seasonal wetlands for hunting waterfowl, while flooded rice fields provide additional wetland habitat. Tule and cattail predominate the fresh water marshes in the bypass. Open water habitat is found in managed wetland areas, sloughs and canals, permanent ponds and natural features, and delta channels. Wetlands provide foraging and roosting habitat for shorebirds, ducks, geese, swans, pelicans, blue herons, cormorants, great egrets and other birds, while also supporting various aquatic wildlife.

Riparian habitat in the bypass is generally limited to narrow bands of riparian growth along irrigation canals and tributary streams. A large area of mixed riparian habitat has developed immediately south of the Fremont Weir on sediments deposited by the 1997 flood. Other areas of concentrated riparian growth are found along the drainage channel adjacent to the east levee and in tidal sloughs surrounding Little Holland Tract and Liberty Island. Riparian habitats in the bypass include cottonwood, willow, sycamore, and other vegetation that supports various birds and other wildlife. Although valley oak woodlands once dominated the high terraces of the Yolo Basin, it is estimated that agricultural conversion has reduced this habitat type to less than 70 acres (Yolo Bypass Management Strategy, 2001).

Water in the Yolo Bypass results from seasonal flooding in the winter and spring, agricultural return drainage, and tidal backwater in the lower half of the bypass. Spills over the Fremont Weir are the principal cause of widespread inundation of the bypass. Historically, spills at the Sacramento Weir have only occurred during those times when flow is spilling over the Fremont Weir. Contribution from the four main tributaries, Cache Creek, Putah Creek, Willow Slough, and the Knights Landing Ridge Cut, is relatively small in comparison to flows over the Fremont and Sacramento weirs. While complete inundation is nearly always attributed to the weirs, the tributaries themselves can cause inundation of portions of the bypass.

Water entering the bypass from the Fremont Weir initially travels along the eastern margin of the bypass due to the natural slope of the land. Overland flow from the weir travels about 40 miles before reentering the Sacramento River near Rio Vista. Flooding in the Yolo Bypass, either before crops have been harvested (fall) or after initial field preparations have begun (spring), can result in crop loss and other agricultural damages. Flooding during these periods is often due to minor flood events that result in relatively small spills over the weirs and do not inundate the entire bypass. When completely inundated, flow in the bypass is relatively shallow with an average depth of less than six feet, depending upon the magnitude of flow. Winter and spring flood flows in the bypass attract migratory fish and provide spawning and rearing habitat for many sensitive special-status fish species. A small fish ladder located in the middle of the Fremont Weir provides upstream passage for migratory fish during flood conditions. Some fish become stranded when floodwaters recede.

When the Fremont Weir is not spilling, the Knights Landing Ridge Cut, Cache Creek, Willow Slough, and Putah Creek are the primary sources of inflow to the Yolo Bypass. During low flow conditions, water in the Colusa Basin Drain flows into the Sacramento River rather than the Knights Landing Ridge Cut. Agricultural return drainage, originating from irrigation water pumped from the Sacramento River or the ground, is a significant contributor to flow in the eastern drainage channel during late summer months.

Currently, a total of 146 special status species have the potential to occur in this region; 39 are listed under FESA or CESA and 90 are included in the CALFED MSCS as potentially occurring in this region. Since these numbers were determined from a preliminary database search, the actual locations and numbers will not be known until specific projects are proposed and biological field inventories are conducted.

The lower Sacramento River region contains the largest concentration of urban development in the Sacramento and San Joaquin River basins. The City of Sacramento is one of the largest cities at risk of flooding in the United States, with over 50 percent of the city within FEMA's Special Flood Hazard Area. Much of Sacramento is located in historic overflow basins that are protected by levees along the Sacramento and American rivers. The water surface elevation in the river during flood events can be much higher than the adjacent ground elevation putting some developed lands at risk of deep and rapid flooding in the event of a levee failure.

High water stages in the Sacramento River can exacerbate flooding in tributary drainages such as the American River, Natomas Cross Canal, the Natomas East Main Drainage Canal and creeks that drain into them. Similarly, the City of West Sacramento is susceptible to flooding from above-normal backwater in the Sacramento Deep Water Ship Channel caused when the Yolo Bypass is flowing at capacity with high water stages. Subsidence and other factors have reduced the capacity of the Knights Landing Ridge Cut, which conveys drainage from the Colusa Basin into the Yolo Bypass. High stages in the Yolo Bypass can affect flows in the Knights Landing Ridge Cut, Colusa Basin Drain, Cache Creek, Putah Creek, Willow Slough and other tributaries.

Levees within the study area along the Sacramento River are generally tall, up to 25 feet high, with wide cross sections. The original project levees were local levees that were modified in the 1930's with sand and clay dredged from the Sacramento River channel. These materials are not ideal for levee construction. Seepage through the sandy levees and through the foundation (sand and cobbles in places) is the primary concern with regard to levee failure. Seepage is exacerbated by high flood stages within the system. Portions of the current flood management system cannot convey the advertised capacity (as described by DWR, 1985). Levee height along the Yolo Bypass varies with topography, but can be up to 25 feet high. Yolo Bypass levees were constructed from materials excavated alongside the levee alignments. Wind driven wave action and bank erosion are the primary problems affecting levee integrity in the bypass.

Construction of flood management and water supply facilities, flood management activities, and urban and agricultural land development in the lower Sacramento River region have drastically modified ecosystem processes and reduced once vast riparian forests and wetlands to intermittent strips of habitat. The result has been a sharp decline in the quantity, diversity, and viability of natural riverine and floodplain habitats and the species that inhabit them. Limited hydraulic capacity within the Sacramento River and Yolo Bypass is a major constraint on ecosystem restoration within the region. Without major structural modifications of the flood management system, existing and proposed wildlife areas in the Yolo Bypass are limited due to adverse hydraulic impacts. For example, the Vic Fazio Wildlife Refuge south of the I-80 causeway is restricted to management of primarily low cover seasonal wetland habitats because taller vegetation could reduce the flood conveyance capacity of the Yolo Bypass.

Salmon and other fish migrate up canals in the Yolo Bypass in autumn and winter, often attracted by flood flows. The existing fish ladder at the Fremont Weir is somewhat ineffective and only permits upstream passage during flood events when water flows over the weir. After flood peaks have passed, or during years when water does not flow over the weir, fish can become stranded behind the weir and unable to reach spawning areas in the upper reaches of the Sacramento River.

Although topography and the extent of urban development in the Sacramento area limits opportunities to significantly modify the levees or channel of the lower Sacramento River, there are opportunities to reduce damages in this concentrated urban area by modifying the flow split into the Yolo Bypass. Preliminary modeling indicates that flood stages along the Sacramento

River could be reduced if the Yolo Bypass system was modified to accommodate a greater portion of the flood flows entering the region. Diverting more flood flow into the Yolo Bypass and decreasing stages in the Sacramento River would improve levee reliability, lower flood-induced backwater in tributaries, and provide opportunities for increased riparian vegetation within the floodway. The stage reduction benefits would also extend upstream from the Fremont Weir, unlocking additional opportunities for flood damage reduction and ecosystem restoration in upstream regions of the Sacramento River. Modifications could be made to the Yolo Bypass to accommodate the additional flood flows and, at the same time, provide flood benefits to lands adjacent to the Yolo Bypass.

There are limited opportunities for ecosystem restoration along the highly constrained lower Sacramento River. Levees along this portion of the river tightly follow the river channel. In many places, urban development extends to the levees. However, there are significant opportunities to restore native vegetation and habitat within the Yolo Bypass. Modifications to increase capacity or lower stage in the Yolo Bypass would increase ecosystem restoration opportunities. Despite intense agricultural development, the Yolo Bypass remains a significant ecosystem resource within the region. The bypass represents a continuous, 40-mile open space corridor that is protected from urban development pressure by flood easements. The Yolo Bypass area experiences seasonal and tidal flooding and merges with the complex Delta ecosystem. These unique characteristics present a rare opportunity to restore more diverse habitats, connect existing wildlife areas, improve aquatic habitat and fish migration, and enhance the ecosystem value of agricultural lands in the bypass. These restoration opportunities are consistent with the CALFED goal of managing the Yolo Bypass as an area of seasonal shallow water habitat to enhance native fish and wildlife where compatible with flood management and agriculture. However, most of these habitat opportunities can only be accommodated if stages in the Yolo Bypass are lowered to balance the hydraulic impacts of ecosystem restoration.

The lower Sacramento River region within the SRFCP provides the opportunity to extend local flood damage reduction and ecosystem benefits to upstream regions. Reductions in water surface elevations would extend upstream and improve system levee reliability. Habitat restoration in this region would fill a gap in the ecosystem landscape of the Sacramento Valley, providing an important link between habitat in the Delta and habitat in the Feather and upper Sacramento systems. This connectivity would benefit fish and wildlife system-wide by providing greater access to existing upstream habitat and increasing the chance of successful restoration efforts elsewhere in the system.

Upper San Joaquin River Region

The upper San Joaquin River region is bounded by the Merced River confluence to the north and Friant Dam to the south. The flood management system in the upper San Joaquin River region consists of flood storage in Millerton Lake (Friant Dam) and 195 miles of project levees from Gravelly Ford, along the bypasses, to the San Joaquin and Merced River confluence and into the lower San Joaquin River region. For the most part, these levees define a 52-mile long, parallel, manmade waterway for conveying floodwaters. This flood management system includes flow diversion structures and project levees on the lower reaches of the Fresno River, Berenda Slough, Ash Creek, Owens Creek, and Bear Creek. Much of the mainstem of the upper San Joaquin River does not have project levees, but there are some intermittent local levees. The lower San Joaquin Levee District is responsible for maintaining project levees from the Merced River confluence upstream to Gravelly Ford, as well as maintaining a clear river channel for 96 miles of the San Joaquin River from the Merced River confluence upstream to Gravelly Ford, not including the 12 miles from Mendota Dam upstream to the bifurcation structure.

The western portion of the basin produces about 6 inches of precipitation annually and the eastern portion, originating in the Sierra Nevada Mountains, produces up to 70 inches of precipitation annually. Consequently, most of the surface runoff in the basin flows from the Sierra Nevada Mountains to the floor of the valley, with very little surface drainage from the west. This has moved large quantities of eroded material out of the eastern mountains and foothills into the valley as alluvial fans. For the larger waterways, such as the Merced River, these alluvial fans have progressed far onto the valley floor, displacing the mainstem river channel towards the west and flattening the river slope.

The Federal flood management project on the San Joaquin River was initially authorized by the 1944 Flood Control Act. Upstream of the Merced River confluence, the authorized project consisted of floodwater storage in Millerton Lake (Friant Dam) and a recommendation that California purchase flowage easements on 118,000 acres of land along the upper river. Following the Federal authorization, a network of privately constructed flood protection levees and irrigation water delivery systems was developed that substantially increased land values in the area. Because of the increased land values, and the escalation in flowage easement costs, the State chose to construct a bypass system consisting of levees and channel improvements in lieu of purchasing flowage easements.

The flood management system also includes the following dams on the San Joaquin River and various tributaries:

- **Friant Dam on the San Joaquin River.** Millerton Lake, formed by Friant Dam, has a gross storage capacity of 520,000 acre-feet and a flood management reservation of 170,000 acre-feet. Under flood conditions, informal agreements have allowed flood flows to be diverted from the dam into the Madera and Friant-Kern canals when capacity is available.

- **Hidden Dam on the Fresno River.** The dam impounds the reservoir known as Hensley Lake, which has a gross pool of 90,000 acre-feet with a flood storage reservation of 65,000 acre-feet.

- **Buchanan Dam on the Chowchilla River.** The reservoir, known as Eastman Lake, has a gross pool of 150,000 acre-feet with 45,000 acre-feet reserved for flood storage.

- **The Merced County Stream Group.** This group consists of five dry dams (Bear, Burns, Owens, Mariposa and Castle) with a total flood storage capacity of 39,500 acre-feet.

- **Kings River Watershed.** This drainage basin is part of the larger Tulare Lake basin, and lies immediately south of the San Joaquin River drainage basin. Flood flows from the Kings River are diverted through Fresno Slough (James Bypass) into the San Joaquin River at Mendota Pool. Pine Flat Dam is the principal flood damage reduction project affecting flood flows discharged from the Kings River.

Due to water supply development, all of the normal stream flow from the headwaters is diverted from the river by the time it reaches Gravelly Ford. Therefore, more than 100 miles of the river contains no natural runoff flow, except during infrequent flood events. Part of the river is used for delivering irrigation water that is imported from the Delta and part of the river usually contains some irrigation return water.

There is perennial streamflow from Friant Dam downstream to Gravelly Ford. Although flow in this reach is highly regulated for water supply withdrawal purposes and portions of the reach have been substantially disturbed by gravel mining, it does support remnant riverine habitats. The uppermost 22 miles, from Friant Dam downstream to the Route 99 bridge, is the San Joaquin River Parkway, which is being planned, developed and managed by the San Joaquin River Parkway and Conservation Trust in partnership with the San Joaquin River Conservancy, a state agency. The goals of the Parkway, a mosaic of private and public lands along the river corridor, include preserving and restoring lands with ecological, scenic and historic significance, providing public education on environmental stewardship, researching river-related issues, and promoting multiple uses consistent with protecting the river's resources.

Currently, a total of 201 special status species have the potential to occur in this region; 45 are listed under FESA or CESA and 82 are included in the CALFED MSCS as potentially occurring in this region. Since these numbers were determined from a preliminary database search, the actual locations and numbers will not be known until specific projects are proposed and biological field inventories are conducted.

A diverse array of public and private interests are directly or indirectly concerned with flood damage reduction and ecosystem restoration considerations along the upper San Joaquin River. Many local interests want better coordination of ongoing studies and programs and a better understanding of the cumulative effects of these on-going programs.

The San Joaquin River Management Program has had several legislative authorizations since it began in 1990. The original authorization required the development of a plan to address flood protection, water supply, water quality, recreation fisheries, and wildlife in the San Joaquin River Basin. This plan, consisting of nearly 80 consensus-based actions, was completed in 1995. Presently, SJRMP provides a regional forum for agriculture, business, industry, recreation and other interests, landowners, local agencies, and environmental groups to work directly with State and Federal agencies to develop solutions to water resource issues in the watershed.

Several communities and agricultural areas in the upper San Joaquin River Basin are subject to a high risk of flooding and functional riverine ecosystems are virtually absent in most of the region. The combined discharges of Friant Dam and Pine Flat Dam have regularly exceeded the system’s design conveyance capacity. Many stakeholders believe that anticipatory releases from Friant Dam could essentially eliminate flood risk in this upper river region. There may be opportunities to modify reservoir operations to make strategic releases that support a more natural hydrologic regime.

Differential subsidence due to groundwater overdraft has adversely affected the performance of the flood management system in this region. Upstream of the area of greatest subsidence the stream gradient has steepened, increasing downcutting of the channel and threatening stability of levees and flow management structures. The eroded material is deposited in the subsided section, reducing its conveyance capacity. A specific example of this problem is in the Chowchilla Canal – Eastside Bypass, where subsidence has caused increased sedimentation that has reduced conveyance capacity. Downstream of the subsided section the stream gradient becomes flatter, also decreasing conveyance capacity.

The full allocation of normal streamflow for water supply and its diversion outside the immediate drainage area has eliminated typical riparian, wetland, and aquatic ecosystems along much of the upper mainstem river. Some natural ecosystems are present in public and private refuges that obtain water from sources other than normal watershed run-off. However, sufficient water is generally not available to support functional riverine ecosystems throughout the length of the river. Another consequence of this altered hydrology is that some reaches of the river are most likely no longer capable of carrying “normal” perennial streamflow, should it be restored in the future. Without providing additional water for more sustained flow conditions in the upper San Joaquin River, the benefits of successfully restoring riverine ecosystems cannot be achieved. There is an on-going joint investigation (unrelated to the Comprehensive Study) by the Friant Water Users Authority and Natural Resources Defense Council (NRDC) in cooperation with the USBR to identify water management strategies that can provide water to the upper river for restoring riparian and aquatic ecosystems. Many believe that this investigation should be completed before any new programs are begun.

The highly altered hydrology of the upper river over the past 50 years has resulted in substantial sediment deposits and in-channel vegetative growth, which have greatly diminished channel conveyance capacity along many reaches of the upper river. Although this has increased the risk of flooding, maintenance activities have been greatly curtailed since the late 1980’s due to environmental legislation regulating these actions.

Substantial rural levee failures occur during major floods. In addition to overbank flooding, agricultural flooding can occur from back-up through irrigation drainage systems and levee seepage during high flow conditions. Flooding by seepage frequently occurs through deeper soil layers, underneath parallel water supply facilities. Seepage transports salts into crop root zones, increasing soil salinity to levels that are toxic to crops. This prevents any crop production until the salts leach from the upper soil layers, which can take up to several years.

The Bifurcation Structure is operated to reduce discharges to the downstream river channel after the start of the irrigation season, which can be as early as the beginning of February in dry years. This is not done to protect the irrigation supply systems from damage, but it is done because water users must pay for floodwaters entering the irrigation supply systems. This constraint on the operation of the system reduces the opportunity to pass floodwaters through this reach of the San Joaquin River as a means to restore the ecosystem.

Project levees in some locations were constructed with relatively pervious materials on inherently unstable foundations of sandy soils, river sediments, and sand lenses. The least reliable project levees are from the Bifurcation Structure upstream to the end of project levees at Gravelly Ford, which experienced nine levee breaks during the 1997 flood. Seepage "boils" along this upstream reach begin to occur as soon as high water reaches the toe of the levee embankment.

Wherever there is informal public access to private property along the river, such as road crossings, there are usually substantial amounts of illegally dumped solid household waste. This is most pronounced where there is natural vegetation to screen this activity. Consequently, local landowners are not supportive of any proposal to increase public access to the river corridor, or to increase the amount of vegetation from ecosystem restoration that could screen illegal dumping.

The USBR's ongoing investigation to identify additional storage opportunities in the Upper San Joaquin River watershed for water supply and related purposes could provide increased storage capacity for seasonal flood flows and for ecosystem restoration. In addition to increased water supplies for agricultural, industrial and municipal uses, some of the increased storage could be used to hold floodwaters and improve the condition of the ecosystem. Additional storage for flood waters could reduce flood risk along the upper San Joaquin River and could enhance the flexibility in operation of Friant Dam. Increased water supply could be used to restore perennial flow to the upper river and the associated ecosystem. Although water for some ecosystem restoration could come through complicated water transfers, crediting, and acquisition, many local and regional interests believe that new water supply is essential for long-term, dependable restoration of riverine ecosystems.

Preliminary analyses of potential flood damage reduction benefits indicate that there are insufficient potential benefits to support planning and construction of a single purpose flood damage reduction project. Therefore, implementing multiple purpose projects in the future that are responsive to the Study's planning objectives is contingent upon other interests providing sufficient water to support ecosystem restoration benefits.

Lower San Joaquin River Region

The lower San Joaquin River flows through the northern half of the San Joaquin River region. This region includes the mainstem of the San Joaquin River from Stockton to the confluence with the Merced River. It includes the lower reaches of the three main tributaries (the Stanislaus, Tuolumne, and Merced Rivers) from their confluences with the San Joaquin River upstream to where the floodplain is confined by the incised natural channel. The region extends into the Delta and includes Paradise Cut and Old River to Tracy Boulevard and Middle River to Victoria Canal.

The San Joaquin River changes from a multi-channel system above the Merced River to a single channel system below. As the San Joaquin River merges with the Merced River, a much larger, single channel is formed. The San Joaquin River carries year-round flow to the Delta, with summer flows being contributed by the three main tributaries. In the reach from the Merced River to the Tuolumne River, the floodplain of the San Joaquin River is constricted by natural topography. Project levees are intermittent, protecting specific areas of the floodplain and then tying back into high ground away from the river. As the San Joaquin River approaches the Tuolumne and Stanislaus Rivers, the floodplain widens to form broad triangular-shaped confluences.

Downstream from the Stanislaus River confluence, the San Joaquin River passes the Vernalis gaging station, the general area where the river becomes tidally influenced. At Paradise Cut, the San Joaquin River becomes a distributary system, dividing its flows between several channels as it winds through the Delta. During a flood event, concurrent high flows from the Sacramento, Cosumnes, and Mokelumne rivers physically limit the amount of flow that can drain out of the San Joaquin River, causing flood flows to pond in the south Delta area.

The 1944 Flood Control Act for the lower San Joaquin River and Tributaries Project authorized Federal flood control work in the basin. Additional modifications were made in the mid 1980's. The Federally constructed portion of the project consists of about 100 miles of intermittent levees along the San Joaquin River, Paradise Cut, Old River and the lower reaches of the Stanislaus and Tuolumne rivers. The levees vary in height from about 15 feet at the downstream end to an average of 6 to 8 feet over much of the project.

Each of the main tributaries of the lower San Joaquin River has a large dam and reservoir that includes storage for flood control. Each dam is operated to reduce floodflows on its downstream river and has a secondary objective of reducing floodflows along the lower San Joaquin River. Friant Dam, located outside the study area for the lower San Joaquin regional project, has flood control space within its reservoir, and affects flows in the San Joaquin River. Dams within the lower San Joaquin River region include:

- **New Exchequer Dam on the Merced River**. The reservoir has a storage capacity of just over 1 million acre-feet, of which 350,000 acre-feet are reserved for flood control.

- **New Don Pedro Dam on the Tuolumne River**. The reservoir holds about 2 million acre-feet and has 340,000 acre-feet reserved for flood control storage.

- **New Melones Dam on the Stanislaus River.** The reservoir has a storage capacity of 2.4 million acre-feet with 450,000 acre-feet reserved for flood control storage.

Portions of the current flood management system cannot convey the advertised capacity. The advertised capacity is the flow capacity that DWR believed was available for the system in 1985.

Development of the San Joaquin River basin's water resources has heavily modified the basin's hydrology. The San Joaquin River is now artificially regulated to meet irrigation and flood management needs. Prior to alteration of the hydrologic regime, the San Joaquin River was extremely variable. Changes to the system have reduced the amount of water available to support the river processes, native vegetation, the frequency and duration of high flows, and the seasonal variability of flows. Hydrologic changes, combined with gold and gravel mining disturbances, levee and bypass construction, and dam-related modifications of sediment continuity have caused a significant change in the river's geomorphology. These caused significant effects on establishment and survival of riparian and wetland vegetation and on the quality of the associated aquatic habitat. These effects have contributed to declining populations of many plant, fish, and wildlife species associated with these habitats.

Currently, a total of 154 special status species have the potential to occur in this region; 37 are listed under FESA or CESA and 91 are included in the CALFED MSCS as potentially occurring in this region. Since these numbers were determined from a preliminary database search, the actual locations and numbers will not be known until specific projects are proposed and biological field inventories are conducted.

Past farming practices directed sediment-laden agricultural drainage from surrounding fields into low-lying areas near the river to assist farmers in those areas who were attempting to fill in and grade flood terraces and oxbow lakes to make them suitable for farming. Additionally, imported irrigation water from both State and Federal projects contributed to the sediment loading by also directing agricultural return flows to the river through "wasteways." These wasteways were originally intended to carry excess flows from the canals back to the river. Since the wasteways cut off older drainage ditches, agreements were made to allow the farmers to discharge their agricultural tailwater into them. This has caused substantial sedimentation to occur, both in the "wasteways" themselves and in the receiving river channel. Current practices are attempting to retain agricultural tailwater on site. Upstream diversions on the San Joaquin River and tributaries have reduced the frequency of flooding, thereby reducing the opportunity to flush the accumulated sediment out of the river system. Downstream landowners who are impacted by this accumulation of sediment are seeking help with sediment management, possibly by periodic dredging.

The State Water Resources Control Board recently ended a policy of exempting agricultural practices from water quality standards. Beginning in January 2003, agricultural drainage will be subject to water quality testing similar to urban and industrial areas. Agricultural groups are concerned about the implications of this decision on farming practices and how it could be affected by changes in the flood management system.

SJRMP has had several legislative authorizations since it began in 1990. The original authorization required the development of a plan to address flood protection, water supply, water quality, recreation fisheries, and wildlife in the San Joaquin River Basin. This plan, consisting of nearly 80 consensus-based actions, was completed in 1995. Presently, SJRMP provides a regional forum for agriculture, business, industry, recreation and other interests, landowners, local agencies, and environmental groups to work directly with State and Federal agencies to develop solutions to water resource issues in the watershed.

Within the study area, particularly on the left bank or the west side of the San Joaquin River, substantial opportunities exist to acquire in fee title or purchase easements on flood-prone land and breach or remove existing project and non-project levees. The floodplain of the San Joaquin River is constrained in this area by topography and the existing levees protect small areas from flooding. By opening up the floodplain, more floodwater would be attenuated, accumulated sediment would be removed from the channel and deposited on the floodplain, and restoration of riparian and wetland habitat could occur in selected areas. Compatible agriculture could continue in portions of the new designated floodway. In the reach between the Stanislaus River and Paradise Cut, some stakeholders support a backup levee system that would allow floodwaters to spill out over agricultural fields when the river stage reaches a certain level.

The lower portion of the study reach, between the Stockton and Tracy urban areas, has experienced significant development within the last decade. Residential areas are located in low-lying areas immediately adjacent to the levee system along much of the right bank of the San Joaquin River south of Stockton. South Delta islands that have functioned in the past as overflow areas are being considered for urban development. The flood management system in this area was originally designed to protect agricultural land uses, and so the levees were not constructed with as high a degree of reliability as those in urban areas. Consequently, the public may underestimate the risk of flooding in these areas. Increasing conveyance capacity and diverting more flows through Paradise Cut and Old River, away from the San Joaquin River, would allow for more effective conveyance within the South Delta and would direct flows away from the existing urbanized areas. This could include levee realignments that would create an opportunity for riparian restoration.

Opportunities exist in this region to work with other Federal, State and locally held lands that have either been purchased for habitat restoration or have conservation easements. The landowners and managers of these areas have a high degree of interest in establishing overbank flooding by removing, breaching or setting back levees. The U.S. Fish and Wildlife Service (Service) currently plans passive levee breaches for the San Joaquin River National Wildlife Refuge near the Tuolumne River confluence. The Service is potentially interested in constructing control weirs that would allow these areas to be used for flood attenuation.

There are opportunities to improve the effectiveness of existing reservoirs in managing floods on the Merced, Tuolumne, Stanislaus, and Lower San Joaquin rivers. The level of flood protection provided by these reservoirs could be increased by reoperation or physical improvements to the dams. Operational criteria could be modified to coordinate releases or to accommodate forecast-based operations (also termed pre-releases). There are also opportunities to use these reservoirs to make strategic releases that support a more natural hydrologic regime. This would improve recruitment of riparian vegetation and restore ecosystem functions. The operators of New Exchequer Dam on the Merced River and New Don Pedro Dam on the Tuolumne River are interested in increasing the objective release from these dams to reduce damages from flooding. This could allow the operators greater flexibility in evacuating the flood management space in advance of storms.